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Analysis of Long-Term No Emission Data from Pulverized Coal-Fired Utility Boilers
Volume I. Technical Analysis

KVB, Inc.
Irvine, CA

Prepared for

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ANALYSIS OF LONG-TERM NO EMISSION DATA FROM PULVERIZED COAL-FIRED UTILITY BOILERS

VOLUME I. TECHNICAL ANALYSIS

by

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a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
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Nitrogen Oxide (NO)		Stationary Sources	07B	
Coal	Analyzing		21D	14B
Pulverized Fuels				
Combustion			21B	
Boilers			13A	

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ABSTRACT

Long-term NO emission monitoring data obtained from nine pulverized coal-fired utility boilers were analyzed. These data were in the form of hourly-averaged NO, O_2 (or CO_2) and load with NO and O_2/CO_2 being measured by certified continuous emission monitors. The analyses were compared to the emissions limitations enumerated in both the 1971 and 1978 New Source Performance Standards (NSPS).

The comparison with the 1978 NSPS showed that seven of the nine boilers would have produced no periods of excess NO emissions on a 30-day rolling average basis. In addition, the same seven boilers would have complied with the 1978 NSPS NO_x performance test requirements.

Recommendations are made to more fully analyze the operation of two of these boilers to establish if their mode of operation could be adopted by other boilers. These boilers use permanently installed CO monitors to allow operation at the lowest practical excess air to achieve either low NO emissions or better fuel efficiency.

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SECTION 1.0

OBJECTIVES AND APPROACH

The objective of this study was to analyze long-term continuous emission monitoring data from a variety of pulverized coal-fired utility boiler designs and operating modes for the purpose of determining the degree to which the characteristics of these boilers could comply with the 1978 New Source Performance Standard (NSPS) for NO_x (40 CFR 60.40a et seq.).* The 1978 NSPS sets forth NO_x limitations, in terms of the coal-type used, which must not be exceeded during the initial boiler performance test, and defines periods of excess emissions on a 30-day rolling average basis. Table 1-1 summarizes the NO_x standards.

The data to be analyzed was to be obtained from boilers equipped with certified continuous emission monitors (CEM). Of necessity, the boilers which were to be analyzed would themselves be subject to the 1971 NSPS, since these units were usually required to install CEMs. (If the NO_x measured during the performance test was less than 70 percent of the standard then continuous NO_x monitoring was not required.)

During a previous EPA study, KVB had contacted various utilities operating boilers equipped with CEMs, to solicit their participation in the present study. Information requested consisted of:

1. Hourly-averages of NO_x, O_2(or CO_2)† and load.
2. Monitor certification results.
3. Periodic coal analyses.
4. Boiler design features incorporated specifically for NO_x control.

---

*This NSPS, although promulgated in 1979, affects electric utility steam generators for which construction commenced after September 18, 1978.

†The 1971 NSPS allows the use of either O_2 or CO_2 as a dilution correction. CO_2 was used on only one boiler.

TABLE 1. SUMMARY OF 1971 AND 1978 COAL NO_x NSPS

1971

Coal Type	NO_x	
	ng/J	$lb/10^6$ Btu
Subbituminous	300	0.70
Bituminous	300	0.70
Lignite (Dakotas or Montana)	340	0.80
Other Lignites	260	0.60
3-Hour Averaging Period (Rolling or Block)		

1978

Coal Type	NO_x	
	ng/J	$lb/10^6$ Btu
Subbituminous	210	0.50
Bituminous	260	0.60
Lignite (Dakotas or Montana)	340	0.80
Other Lignites	260	0.60
30-Day Rolling Average		

Nine boilers were included in the study. Site visits were made to seven of the nine boilers in order to discuss monitor and boiler operation with the appropriate personnel. Detailed information on an eighth unit was obtained by letter. A site visit to the remaining unit had been made during the previous study. The purpose of these visits was to gather the following detailed information, i.e.:

1. Monitor calibration method and frequency.
2. Monitor maintenance procedures.
3. Monitor recertification results (if performed).
4. Boiler slagging, fouling or tube wastage problems.
5. Operation of boiler NO_x controls.
6. Explanation of monitor and/or boiler outages.

The primary purpose of these visits was to validate the monitor data supplied. It was not the intent to perform an in-depth audit of the monitor system. In the event that the site visit indicated that some of the data supplied was questionable, these data were deleted and a revised computer analysis was performed.

The coal analyses supplied by the utility were analyzed for consistency over the monitoring period. No attempt was made to correlate the emissions with coal properties since this activity was outside the scope of the assignment. In addition, the periodic coal analyses consisted, for the most part, of a proximate analysis for which the fuel-bound nitrogen component was not available. Fuel nitrogen content is reported when available.

Of particular interest was the CEM data obtained on nominally identical boilers operated by the same utility and firing the same coal. It was anticipated that the commonality in boiler design and operating features, and coal properties would produce similar emission characteristics. This similarity, however, was not always realized.

The site visits verified that all the monitoring systems were measuring nitrogen oxide (NO) only and not total oxides of nitrogen ($NO_x = NO + NO_2$). In addition, none of the CEMs made any correction for NO_2. According to Reference 1, nitrogen dioxide (NO_2) represents about 3 percent of the total NO_x for coal fueled industrial boilers, and it is assumed that the same proportion would be applicable for coal fueled utility boilers. Thus, if the monitors were entirely accurate they would be under-measuring total NO_x by approximately 3 percent.

Table 1-2 summarizes the pertinent information on the nine boilers analyzed during this assignment. Subsequent sections are devoted to each boiler.

TABLE 1-2. BOILER PERTINENT INFORMATION

Utility	Station	Unit	Coal Type(1)	Boiler Mfg.(2)	Gross MWe	NO$_x$ Controls(3)	Site Visit
Oklahoma Gas & Electric	Muskogee	4	Sub.	CE	550	Tang. + OFA	Yes
		5	Sub.	CE	550	Tang. + OFA	Yes
Omaha Public Power District	Nebraska City	1	Sub.	FW	575	Interstage air	No
Iowa Power & Light	Council Bluffs	3	Sub	B&W	720	DRB	Yes
Pennsylvania Electric	Homer City	3	Bit.	B&W	680	DRB	Yes
Louisville G & E	Mill Creek	3	Bit.	B&W	425	DRB	No(4)
Proprietary	--	A	Sub.	CE	350	Tang. + OFA	Yes
		B	Sub.	CE	350	Tang. + OFA	Yes
Public Service New Mexico	San Juan	1	Sub.	FW	360	OFA + DRB	Yes

(1) Sub. = Subbituminous
Bit. = Bituminous

(2) CE = Combustion Engineering
FW = Foster Wheeler
B&W = Babcock & Wilcox

(3) Tang. = Tilting tangential
OFA = Overfire air
DRB = Dual register burner

(4) Detailed information obtained by letter.

SECTION 2.0

DATA ANALYSIS AND VALIDATION

The data packages received from the utilities were initially examined to verify that all the information requested was included. The hourly-averaged values of NO*, O_2/CO_2 and load were examined in more detail to assure that there were no missing data and that the entries were legible. Any discrepancies noted were resolved directly with the utility.

The hourly-averaged data was transferred to computer input sheets and the initial computer run was performed. The boiler characteristics (NO and O_2/CO_2 versus load) were plotted to identify any unusual trends which should be discussed further during the site visit. Plots were also prepared for the load and NO cumulative probability distributions.

Site visits were made to seven of the nine boilers analyzed during this assignment. Information on another unit was obtained by letter. The purpose of these visits was to hold detailed discussions with the appropriate station personnel. The topics discussed included:

1. Boiler Design
    a. Boiler description
       number of burners and burner arrangement
       heat release rate
    b. Operation of dual register burners and/or overfire air system

2. Boiler Operation
    a. Oxygen versus load
    b. Heat rate
    c. Steam temperature problems
    d. Slagging/fouling characteristics
    e. Unit availability/load limitations
    f. Ash carbon characteristics

---

*The determination that only NO data was supplied was not made until the site visits. The wet chemical Method 7 performance test results, as required by the 1971 NSPS, are the only data presented which are for total NO_x. On a mass basis, ng/J or $lb/10^6$ Btu, NO and NO_x are in terms of NO_2.

   g. Tube wastage
   h. NO excess emissions

3. CEM System
   a. Make and model
   b. NO_x or NO only
   c. Sampling location
   d. Data reduction procedure
   e. Recertification
   f. Calibration procedure
      frequency, out-of-calibration flag, corrective action
   g. Quality assurance program

4. Coal Supply
   a. Source
   b. Nominal characteristics and variability

If the site visit identified some of the data as being of questionable validity then a revised computer analysis was performed with these data deleted.

2.1 DATA EDITING CRITERIA

The data sets supplied by the utilities consisted of hourly-averaged NO, O_2 (or CO_2) and load. Data obtained by KVB at Mill Creek Unit 3, under subcontract to Exxon, was on a 15 minute-averaged basis.*

Each of the data sets was reviewed prior to the preliminary computer analysis to establish its initial validity. Final data validation occurs after visiting each plant and discussing the data with the personnel responsible for monitor operation, maintenance, calibration, etc.

The initial review was performed subject to the following criteria:

1. Values of NO, O_2 (or CO_2) and load are required for each hour, otherwise the hour will be deemed invalid.

2. For the monitoring performed by KVB at least three 15-minute periods of NO, O_2 and load are required to produce a valid hour.

---

*KVB's use of a data-logger allowed the data to be averaged over any period, and a 15 minute period was chosen for convenience. These data were subsequently combined to yield the hourly-averages required by the computer program.

3. A day must contain at least 18 valid hours, otherwise the entire day will be deemed invalid.

2.2 DATA REDUCTION COMPUTER PROGRAM

A KVB program was specially modified for this Work Assignment to perform the following computations:

1. Daily means and standard deviations of NO, O_2 (or CO_2) and load.
2. Means and standard deviations of NO and O_2/CO_2 as functions of unit load.
3. Load probability.
4. NO probability.
5. Number of periods of excess NO emissions with respect to the 1971 NSPS on both a 3-hour rolling average and 3-hour block average basis.
6. Number of periods of excess NO emissions with respect to the 1978 NSPS on a 30-day rolling average basis.

The program listing is presented in Appendix A, Volume II.

2.2.1 Daily Statistics (Item 1)

A valid day, as previously mentioned, contains at least 18 valid hours. The computation of daily statistics is performed with the valid hourly-averages. On input, an invalid hour is so identified by a value of NO ≤ 0.

2.2.2 Boiler Characteristics (Item 2)

The valid hourly-averaged load is stored in a one-dimensional array which is then searched for both the minimum and maximum values measured. To insure complete coverage, one MWe is added to the maximum load and one MWe is subtracted from the minimum load. The resulting range is then divided into 10 equal cells into which are stored NO and O_2/CO_2 pairs sorted on the basis of the corresponding load. Means and standard deviations are then determined for both NO and O_2/CO_2 in each load cell.

2.2.3 Load Probability (Item 3)

The NO and O_2/CO_2 sorting described above also produces the number of entries within each load cell. These values then define the cumulative load probability:

$$P_j = \frac{\sum_{i=1}^{j} n_i}{N + 1} \times 100 \qquad (1)$$

where:

P_j = cumulative percent probability that load is less than jth value.

n_i = number of entries in ith load cell.

N = total number of entries in all 10 load cells.

2.2.4 NO Probability (Item 4)

The valid hourly-averaged NO values are stored in a separate one-dimensional array which is then searched for both the minimum and maximum. Complete coverage is assured by adding 0.005 $lb/10^6$ Btu (2.2 ng/J) to the maximum NO and subtracting the same amount from the minimum. The resulting range is divided into 10 cells and the hourly-averaged NO is sorted into the cells. The cumulative NO probability is then determined using Equation (1).

2.2.5 1971 NSPS (Item 5)

The array of valid NO is averaged on two bases and compared with the applicable standard. A count is made of the number of times the standard is exceeded.

The first computation determines the NO averaged on a three-hour rolling basis. This involves:

$\overline{NO}$ (1) = Average of hours 1, 2 and 3

$\overline{NO}$ (2) = Average of hours 2, 3 and 4

$\overline{NO}$ (3) = Average of hours 3, 4 and 5

$\vdots \qquad\qquad\qquad \vdots$

For a three-hour block basis:

$\overline{NO}$ (1) = Average of hours 1, 2 and 3

$\overline{NO}$ (2) = Average of hours 4, 5 and 6

$\overline{NO}$ (3) = Average of hours 7, 8 and 9

$\vdots \qquad\qquad\qquad \vdots$

2.2.6 1978 NSPS (Item 6)

The array of valid daily mean NO is averaged on a 30-day rolling average basis and compared to the applicable standard. A count is made of the number of times the standard is exceeded. The program prints both the exceedance count and the 30-day averages.

2.2.7 Exceedance Definition

Each of the NO averages are truncated to three significant figures and compared to the emission limitation which is similarly truncated. If the difference is five or more (either 5 ng/J or 0.005 lb/10^6 Btu), then the exceedance flag is incremented.

2.2.8 1971 and 1978 NSPS Requirements

The 1971 NSPS has two distinct NO_x requirements:

1. Performance test

2. Continuous monitoring

The first requirement involves obtaining twelve Method 7 grab samples within a three-hour period during which time the unit is operated at full output. These samples are analyzed for total NO_x concentration and, after conversion to units of the standard (ng/J - $lb/10^6$ Btu), are compared to the NO_x limitation (40CFR 60.44). Thus, the performance test is conducted at one-point-in-time and at full output.

The continuous monitoring requirement, using certified analyzers, is to determine hourly-averaged values of NO* and O_2 or CO_2 in volumetric units. These measurements are used to compute NO (in units of ng/J or $lb/10^6$ Btu as NO_2) on a three-hour basis (rolling or block) which are then compared to the standard. Periods of emissions in excess of the standard are reported to the applicable regulatory agency on a quarterly basis together with a description of the corrective action taken by the utility to eliminate the periods of excess emission.

By comparison, the 1978 NSPS performance test, as required under 60.46a (f) and (g), is the average of all the hourly-averaged NO, as measured by certified analyzers, for the first 30-days of full operation.

Continuous monitoring is also required after the performance test to establish the subsequent 30-day rolling averages in terms of the daily-averaged NO:

$\overline{NO}$ (1) = Average of daily NO for days 1 - 30

$\overline{NO}$ (2) = Average of daily NO for days 2 - 31

$\overline{NO}$ (3) = Average of daily NO for days 3 - 32

$\vdots \qquad\qquad\qquad \vdots$

---

*The EPA allows the use of NO-only analyzers to satisfy the requirement to measure "oxides of nitrogen."

2.3 COMPUTER PROGRAM INPUT

The program is dimensioned to accept up to 100 days of hourly-averaged NO, O_2/CO_2 and load. Therefore, a maximum of 2400 values of each parameter can be input.

2.3.1 Input Section 1 - Heading Information

Six heading cards are input first and are free-form in card columns 1-72. These cards are immediately written out. Six cards, even if they are blank, must be provided. Card columns 73-80 are available for identification punch on all input cards.

2.3.2 Input Section 2 - Number of Days, Coal Type, Performance NO_x

Format: 2I6, F6.3 (NDAYS, ICØAL, PERFM)

The first variable, NDAYS, is the total number of days of NO, O_2/CO_2 and load to be read-in subject to NDAYS $\leq$ 100. The coal type (ICØAL) is used to select the appropriate NO_x emission limitation as set forth in the 1971 and 1978 NSPS.

ICØAL	Coal Type
-1	Subbituminous
0	Bituminous
1	Lignite mined in the Dakotas or Montana and used in a cyclone-fired unit
2	Other lignites

PERFM is the NO_x measured during the initial performance test (as required by the 1971 NSPS) and is in units of $lb/10^6$ Btu. This Method 7 measurement is in terms of total NO_x ($NO + NO_2$).

2.3.3 Input Section 3 - Sequential Day

Format: I6 (IDAY(I))

This array, IDAY(I), I = 1, ..., NDAYS, serves as an identification of the NO, O_2/CO_2 and load data which follows. An IDAY (I) value ≤ 0 indicates an invalid day, for which the NO, O_2/CO_2 and load are not input.

2.3.4 Input Section 4 - Hourly-Averages

Format: 12F6.3/12F6.3

The hourly-averaged NO, O_2/CO_2 and load are input in this order, two cards per variable, six cards total. An invalid hour is input with a value of NO ≤ 0. The units of NO are lb/10^6 Btu; volume percent for O_2 or CO_2, and, gross MWe for load.

2.3.5 Sample Input

Table 2-1 is an input sample which illustrates all the input sections. The first six lines are the free-form heading information which is also part of the program output.

The seventh line indicates that: a total of 64 (NDAYS) days of information follows; the boiler was fired with a bituminous coal (ICØAL = 0), and; the NO_x measured during the 1971 NSPS performance test was 0.623 lb/10^6 Btu (PERFM).

For this particular unit the 64 days of monitoring data was obtained during two time periods:

January 19, 1981 through February 20, 1981 and
March 24, 1981 through April 23, 1981

The NO monitor relative accuracy was determined during both time periods and is noted in the heading cards.

The NO, O_2 and load hourly-averages for the first day, IDAY(1) = 1, are contained on the following six cards. As noted, the values measured during the first hour on the first day were:

NO = 0.528 lb/10^6 Btu

O_2 = 10.7%

Load = 198. MWe gross

TABLE 2-1. SAMPLE COMPUTER INPUT

```
LOUISVILLE GAS AND ELEC.  MILL CREEK UNIT 3
B+W BOILER DUAL REGISTER BURNERS
425 MWE GROSS  LOW VOLATILE BITUMINOUS
PERFORMANCE NOX = 0.623 LB/10**6BTU, 268NG/J
NO  MONITOR REL. ACC. = 17.8PC, =12.4PC
DAY 1 = 1/19/81, DAY 34 = 3/24/81
   64      0 .623
    1
 .528  .535  .54   .561  .566  .578  .562  .586  .702  -1.   -1.   -1.
 .553  .558  .504  .526  .462  .470  .476  .48   .472  .458  .477  .426
 10.7  11.2  11.1  11.4  11.4  11.5  9.7   6.7   7.2   -1.   -1.   -1.
 5.2   4.9   5.1   5.6   5.9   5.9   5.4   4.9   5.1   5.2   5.7   8.0
 198.  198.  196.  196.  196.  195.  196.  195.  193.  -1.   -1.   -1.
 200.  197.  197.  199.  202.  203.  202.  200.  204.  203.  202.  199.
   -2
   -3
    4
 .473  .469  .471  .474  .498  .506  .543  .59   .63   .576  .586  .55
 .571  .472  .533  .457  .436  .41   .433  .405  .412  .41   .403  .399
 5.0   4.9   4.9   4.9   4.7   4.6   4.0   3.1   3.8   5.    5.    4.8
 4.7   3.8   5.1   5.2   5.2   5.    6.1   5.6   5.4   5.3   5.3   5.3
 282.  283.  283.  283.  325.  347.  399.  423.  414.  399.  399.  415.
 387.  388.  312.  278.  281.  281.  269.  271.  271.  272.  267.  264.
    5
 .4    .395  .385  .397  .406  .411  .444  -1.   .378  .489  .518  .504
 .543  .512  .519  .439  .419  .438  .468  .455  .439  .44   .418  .369
 5.2   5.1   4.9   5.    5.    5.    4.9   -1.   8.8   5.    3.7   5.
 4.4   4.3   4.8   5.3   5.1   5.    4.9   5.1   5.    5.9   6.8   7.5
 269.  271.  273.  272.  273.  274.  369.  -1.   236.  400.  384.  387.
 397.  400.  317.  275.  276.  333.  337.  289.  270.  218.  187.  182.
    6
 .36   .363  .351  .343  .354  .364  .38   .386  .375  -1.   .41   .317
 .324  .321  .32   -1.   .444  .437  .433  .446  .462  .444  .42   .389
 7.2   7.2   7.3   7.3   7.1   7.    6.7   6.6   6.5   -1.   6.6   5.5
 5.3   5.3   5.3   -1.   6.4   6.4   6.3   6.4   6.3   6.3   6.7   8.9
 183.  183.  167.  172.  181.  200.  212.  209.  208.  -1.   251.  256.
 262.  257.  256.  -1.   259.  258.  260.  259.  259.  255.  206.  197.
```

No valid data were obtained for hours 10, 11 and 12 during the first day as indicated by the -1. entries.

Insufficient valid data was obtained for the following two days (IDAY(2) = -2, IDAY(3) = -3). For invalid days the six NO, O_2/CO_2 and load cards must be omitted.

2.4 COMPUTER PROGRAM OUTPUT

The computer program output, as illustrated in Table 2-2, consists of:

1. A title line and the six heading cards.
2. The hourly-averaged input data. The conversion from $lb/10^6$ Btu to ng/J is 429.591. For illustrative purposes, only a portion of the input data is shown in Table 2-2. The full input data for each boiler is contained in an appendix in Volume II.
3. The daily statistics. Invalid days are not shown and can be identified by a break in the "DAY" column, e.g., days 11-15 are invalid.
4. Boiler characteristics--hourly-averaged NO and O_2/CO_2 versus load. As previously mentioned the difference between maximum and minimum load is divided into 10 cells with the load cell dimensions noted in the top part of the output page. For example, load cell 10 extends from 642 to 708 MWe gross and is centered at 675 MWe gross. The lower portion of the output page shows the NO and O_2/CO_2 boiler characteristics versus boiler load. The particular boiler chosen for illustrative purposes is base-loaded as evidenced by the cumulative load probability results, i.e., over 85 percent of the hourly-averaged loads were equal to or greater than 642 MWe gross (94 percent of rated generator output). The few number of instances of low load correspond to the boiler operating in either a shut-down or start-up transient.
5. NO probability is output next. The upper portion of the output page defines the NO cell dimensions, obtained by dividing the NO range into 10 increments. The lower portion of the page presents the cumulative NO probability, i.e., 99.38 percent of the hourly-averaged NO readings were less than 336 ng/J (0.783 $lb/10^6$ Btu).

(text continued on page 2-18)

TABLE 2-2. SAMPLE COMPUTER OUTPUT

```
                          **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
UTILITY XYZ, UNIT F
B+W BOILER OPPOSED FACE-FIRED
680 MWE GROSS          DAY 1 - 1 MAY 1979
DUAL REGISTER BURNERS  BITUMINOUS COAL
NO  MONITOR RELATIVE ACCURACY = 12.4 PC
PERFORMANCE TEST NOX = 0.68 LB/10**6 BTU, 292 NG/J
```

(continued)

TABLE 2-2. (CONTINUED)

INPUT DATA

DAY = 1

HOUR	NO LB/10**6 BTU	NO NG/J	O2 PERCENT	GROSS OUTPUT MW
1	.530	228.	8.0	447.
2	.530	228.	8.0	451.
3	.530	228.	8.0	452.
4	.530	228.	8.0	457.
5	.530	228.	8.0	455.
6	.530	228.	8.0	449.
7	.530	228.	8.0	450.
8	.590	253.	8.0	455.
9	.590	253.	8.0	454.
10	.590	253.	8.0	450.
11	.590	253.	8.0	448.
12	.590	253.	8.0	449.
13	.590	253.	8.0	454.
14	.590	253.	8.0	450.
15	.590	253.	8.0	449.
16	.590	253.	8.0	452.
17	.590	253.	8.0	448.
18	.530	228.	8.0	450.
19	.530	228.	8.0	449.
20	.530	228.	8.0	446.
21	.530	228.	8.0	451.
22	.530	228.	8.0	451.
23	.530	228.	8.0	448.
24	.530	228.	8.0	453.

DAY = 2

HOUR	NO LB/10**6 BTU	NO NG/J	O2 PERCENT	GROSS OUTPUT MW
1	.530	228.	8.0	450.
2	.530	228.	8.0	449.
3	.540	232.	8.2	448.
4	.530	228.	8.0	449.
5	.590	253.	8.0	455.
6	.540	232.	8.2	460.
7	.600	258.	8.2	452.
8	.590	253.	8.0	452.
9	.590	253.	8.0	452.
10	.610	262.	8.5	453.
11	.550	236.	8.5	452.
12	.560	241.	8.8	452.
13	.550	236.	8.5	449.
14	.550	236.	8.5	453.
15	.550	236.	8.5	452.
16	.550	236.	8.5	450.
17	.550	236.	8.5	448.
18	.550	236.	8.5	446.
19	.550	236.	8.5	446.
20	.550	236.	8.5	447.

(continued)

TABLE 2-2. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
1	.555	238.	.0302	13.0	8.8	.08	651.	2.8
2	.557	239.	.0222	9.5	8.4	.23	650.	3.9
3	.628	270.	.0280	12.2	7.2	.57	604.	60.1
4	.662	284.	.0204	8.7	7.1	.18	652.	1.9
5	.684	294.	.0336	14.4	7.0	.07	651.	13.6
6	.663	285.	.0300	12.9	7.0	.09	656.	4.6
7	.625	268.	.0219	9.4	7.1	.13	648.	8.0
8	.601	258.	.0034	1.5	7.0	.08	647.	3.5
9	.596	256.	.0141	6.1	7.0	.08	647.	3.1
10	.601	258.	.0088	3.8	7.8	.08	647.	3.8
16	.645	277.	.0262	11.3	6.7	.15	657.	10.3
17	.660	284.	.0320	13.8	6.7	.27	657.	2.5
18	.637	274.	.0158	6.8	6.6	.28	657.	2.8
19	.633	272.	.0113	4.9	6.6	.16	656.	1.8
20	.614	264.	.0273	11.7	6.6	.12	655.	2.8
21	.618	266.	.0267	11.5	6.6	.30	654.	2.5
22	.627	269.	.0394	16.9	6.6	.12	657.	3.3
23	.610	262.	.0227	9.7	6.7	.30	656.	2.5
24	.638	274.	.0196	8.4	6.8	.13	656.	3.8
25	.642	276.	.0088	1.9	6.8	.11	657.	2.6
26	.645	277.	.0128	5.5	6.9	.16	620.	22.3
27	.647	278.	.0332	14.2	7.1	.48	598.	86.6
30	.650	279.	.0000	.0	7.0	.08	656.	3.5
31	.666	285.	.0357	15.4	7.0	.10	652.	11.2
34	.649	279.	.0080	3.4	6.9	.11	654.	4.7
44	.685	294.	.0169	7.3	6.5	.05	656.	2.7
45	.677	291.	.0246	10.6	6.5	.07	653.	2.8
46	.668	288.	.0297	12.8	6.5	.18	651.	1.7
47	.687	295.	.0183	7.9	6.3	.10	653.	2.0
48	.666	286.	.0286	12.3	6.2	.19	654.	3.0
49	.675	290.	.0184	7.9	6.1	.15	653.	3.6
50	.688	296.	.0215	9.2	6.3	.05	654.	1.9
51	.685	294.	.0372	16.0	6.0	.34	653.	2.7
52	.654	281.	.0252	10.8	5.9	.13	653.	2.9
62	.680	292.	.0316	13.6	6.0	.19	655.	10.8
63	.657	282.	.0275	11.8	6.0	.14	659.	2.3
64	.702	302.	.0354	15.2	6.2	.34	657.	13.5
65	.717	308.	.0477	20.5	6.7	.30	640.	13.8
66	.670	288.	.0494	21.2	6.8	.61	622.	58.2
67	.755	324.	.0341	14.7	7.0	.39	629.	67.3
68	.744	320.	.0532	22.8	6.6	.13	655.	10.0
69	.687	295.	.0070	3.0	6.4	.14	657.	2.1
70	.677	291.	.0307	13.2	6.9	.18	656.	2.8
71	.653	280.	.0125	5.4	6.7	.08	655.	2.7
72	.634	272.	.0295	12.7	6.8	.14	633.	27.0
73	.636	273.	.0118	5.1	6.6	.10	653.	2.6
74	.622	267.	.0122	5.2	6.4	.13	653.	3.3
75	.612	263.	.0280	12.0	6.3	.12	635.	19.8
76	.585	251.	.0232	10.0	6.3	.00	616.	4.2
77	.595	256.	.0234	10.1	6.3	.11	651.	6.0
78	.612	263.	.0236	10.2	6.4	.12	650.	2.0
79	.620	266.	.0174	7.5	6.4	.12	655.	2.6
80	.628	270.	.0042	1.8	6.4	.11	653.	2.0
82	.674	290.	.0846	36.4	6.0	2.35	567.	181.1
83	.697	300.	.0221	9.5	5.8	.10	655.	2.7
84	.704	302.	.0309	13.3	5.8	.13	661.	11.1
88	.697	299.	.0314	13.4	6.4	.13	650.	5.0
89	.690	296.	.0283	12.2	6.3	.10	649.	10.2
90	.686	295.	.0128	5.5	6.3	.14	646.	8.6
91	.697	299.	.0240	10.3	6.4	.13	650.	4.2
92	.687	295.	.0143	6.2	6.4	.13	658.	4.3

TABLE 2-2. (CONTINUED)

NO AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	78.	45.	111.
2	144.	111.	178.
3	211.	178.	244.
4	277.	244.	310.
5	343.	310.	376.
6	410.	376.	443.
7	476.	443.	509.
8	542.	509.	575.
9	609.	575.	642.
10	675.	642.	708.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO. MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD PROB. PERCENT
1	1	.410	176.	.0000	.0	14.50	.00	.07
2	1	.570	245.	.0000	.0	12.00	.00	.14
3	0	.000	0.	.0000	.0	.00	.00	.14
4	1	.490	210.	.0000	.0	9.00	.00	.21
5	0	.000	0.	.0000	.0	.00	.00	.21
6	8	.651	280.	.0653	28.1	7.78	.47	.75
7	54	.564	242.	.0366	15.7	8.13	.30	4.46
8	9	.636	273.	.0536	23.0	7.06	.54	5.07
9	133	.653	281.	.0625	26.9	6.64	.37	14.19
10	1251	.657	282.	.0422	18.1	6.53	.38	99.93

(continued)

TABLE 2-2. (CONTINUED)

NO PROBABILITY

NO CELL DIMENSIONS

CELL NUMBER	CENTER LB/10**6 BTU	CENTER NG/J	LOWER BOUNDARY LB/10**6 BTU	LOWER BOUNDARY NG/J	UPPER BOUNDARY LB/10**6 BTU	UPPER BOUNDARY NG/J
1	.426	183.	.405	174.	.447	192.
2	.468	201.	.447	192.	.489	210.
3	.510	219.	.489	210.	.531	228.
4	.552	237.	.531	228.	.573	246.
5	.594	255.	.573	246.	.615	264.
6	.636	273.	.615	264.	.657	282.
7	.678	291.	.657	282.	.699	300.
8	.720	309.	.699	300.	.741	318.
9	.762	327.	.741	318.	.783	336.
10	.804	345.	.783	336.	.825	354.

NO PROBABILITY RESULTS

CELL NUMBER	NUMBER OF ENTRIES	CUM. PROB. PERCENT LESS THAN
1	1	.07
2	0	.07
3	19	1.37
4	56	5.21
5	195	18.57
6	556	56.68
7	430	86.15
8	143	95.96
9	50	99.38
10	8	99.93

(continued)

TABLE 2-2. (CONTINUED)

NOX COMPLIANCE WITH RESPECT TO 1971 NSPS

FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)

FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)

FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)

FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)

THIS BOILER WAS OPERATED WITH BITUMINOUS COAL

THE NOX MEASURED DURING THE PERFORMANCE TEST WAS .680 LB/10**6 BTU (292. NG/J)

AN ANALYSIS OF 3-HOUR NO ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)

INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON 161 OCCASIONS

AN ANALYSIS OF 3-HOUR NO BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)

INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON 60 OCCASIONS

(continued)

TABLE 2-2. (CONTINUED)

```
                **NOX COMPLIANCE WITH RESPECT TO 1978 NSPS**

                   1978 NSPS NOX EMISSION LIMITATIONS
          SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
            BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
  LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
             OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)


 ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED   32  EXCEEDANCES

                    30-DAY ROLLING AVERAGES
       EMISSION LIMITATION  .60 LB/10**6 BTU  258. NG/J

             SEQUENTIAL            30-DAY AVERAGE NO
              AVERAGE             LB/10**6 BTU  NG/J
             ----------           ------------  ----
                 1                    .637      274.
                 2                    .641      275.
                 3                    .646      277.
                 4                    .647      278.
                 5                    .647      278.
                 6                    .647      278.
                 7                    .647      278.
                 8                    .650      279.
                 9                    .653      281.
                10                    .656      282.
                11                    .661      284.
                12                    .664      285.
                13                    .665      286.
                14                    .667      286.
                15                    .667      287.
                16                    .668      287.
                17                    .668      287.
                18                    .668      287.
                19                    .668      287.
                20                    .667      286.
                21                    .665      286.
                22                    .664      285.
                23                    .663      285.
                24                    .663      285.
                25                    .663      285.
                26                    .665      285.
                27                    .665      286.
                28                    .666      286.
                29                    .667      286.
                30                    .667      286.
                31                    .668      287.
                32                    .668      287.
```

6. The number of excess NO emission periods, with respect to the 1971 NSPS, are calculated on 3-hour rolling average and 3-hour block average bases. As noted, there can be a significant difference between these bases:

   161 exceedances for 3-hour rolling average
   60 exceedances for a 3-hour block average

   This difference is because a NO "spike" can affect 3-rolling averages and only 1-block average.

7. The last section of output is a hypothetical result since none of the boilers analyzed are subject to the 1978 NSPS. With this in mind, the analysis of this particular boiler indicated:

   a. The first 30-day rolling average, which is the counterpart of the 1971 NSPS performance test, would have exceeded the 1978 NSPS standard for bituminous coal (260 ng/J--0.60 lb/10^6 Btu).

   b. All of the remaining 30-day rolling averages would have been periods of excess NO emissions.

SECTION 3.0

OKLAHOMA GAS & ELECTRIC - MUSKOGEE STATION, UNITS 4 AND 5

3.1 EMISSIONS ANALYSIS

Data supplied for these units covered October 15, 1980 through January 16, 1981, inclusive, and this period corresponds to a maximum of 2,256 hours. Excluding those periods when the boiler was off-line, results in monitor reliability* were 99.7 percent and 99.1 percent for Units 4 and 5, respectively.

Both units were originally described by the utility as being identical, however, the subsequent site visit did identify physical and operational differences. These differences, it was anticipated, should produce higher NO emissions for Unit 5. However, both the initial and revised computer program analyses did not support this position.

Table 3-1 is the initial computer summary for Unit 4 from which Figures 3-1 through 3-3 were prepared.† The NO charateristic exhibits a slightly higher value in the mid-load range than at high-load but is in good agreement with the performance test result. The load probability can only be catagorized in terms of its median value of 405 gross MWe (73.6 percent of rating). The NO probability is representable in log-normal coordinates with a geometric mean of 210 ng/J and geometric dispersion of 1.16.

The initial computer summary for Unit 5 is shown in Table 3-2. The NO characteristic (Figure 3-4) shows a very significant fall-off in the mid- to high-load range. Indeed, the high-load result is about 50 percent of the NO_x value measured during the performance test. This occurrence is presently

(text continued on page 3-19)

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*Monitor reliability is defined as:
(Monitor/boiler operating hours) • 100

†In the interest of clarity only the mean values are shown for the boiler characteristics.

TABLE 3-1. INITIAL COMPUTER ANALYSIS - MUSKOGEE UNIT 4

```
                        **PULVERIZED COAL-FIRED UTILITY BOILER NO EMISSION MONITORING**
DATA SUBMITTED BY OKLAHOMA GAS AND ELECTRIC MUSKOGEE STATION
UNIT 4    SUBBITUMINOUS COAL  NO MON. REL. ACC. = 10.9 PC
______________________________________________________________________________
DAY 1 IS OCTOBER 15, 1980     DAY 94 IS JANUARY 16, 1981
550 MWE, COMBUSTION ENGINEERING BOILER WITH OVERFIRE AIR
COAL PROXIMATE 8815+-57BTU/LB, 0.337+-0.037 PC SULFUR,
 _____________________________________________________________
            4.86+-0.371 PC ASH, 27.73+-0.36 PC MOISTURE
```

(continued)

TABLE 3-1. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
1	.399	171.	.0624	26.8	9.8	.87	189.	27.5
2	.385	165.	.0269	11.5	9.9	.09	180.	.8
3	.466	200.	.0589	25.3	9.0	.87	249.	97.7
4	.389	167.	.0330	14.2	10.0	.08	181.	3.1
5	.416	179.	.0144	6.2	10.1	.04	188.	1.4
6	.499	214.	.0682	29.3	8.6	.98	288.	63.7
7	.463	199.	.0338	14.5	8.8	1.01	286.	66.2
8	.507	218.	.0464	19.9	9.1	.61	252.	47.1
9	.454	195.	.0489	21.0	8.7	1.11	272.	74.7
10	.493	212.	.0253	10.9	9.4	.66	231.	49.8
11	.517	222.	.0531	22.8	9.1	1.20	245.	80.5
12	.446	192.	.0204	8.8	9.3	.71	243.	52.9
13	.436	187.	.0239	10.3	7.9	1.58	345.	107.0
14	.560	240.	.0517	22.2	8.1	.93	322.	62.2
15	.582	250.	.0514	22.1	8.3	.48	317.	32.2
16	.638	274.	.0740	31.8	7.5	.55	360.	46.6
17	.562	241.	.0677	29.1	7.7	1.18	350.	84.2
18	.482	207.	.0506	21.7	9.4	.51	228.	39.4
19	.482	207.	.0450	19.3	9.2	.62	235.	47.8
20	.530	228.	.0692	29.7	7.5	1.40	363.	101.3
21	.534	229.	.0659	28.3	7.2	1.26	371.	91.1
22	.487	209.	.0594	25.5	7.6	.86	348.	67.1
23	.479	206.	.0580	24.9	8.0	1.39	309.	93.6
24	.485	208.	.0527	22.7	7.9	1.56	312.	106.7
25	.483	208.	.0775	33.3	8.5	1.41	269.	98.0
26	.457	196.	.0657	28.2	9.7	.90	199.	35.2
27	.500	215.	.0273	11.7	7.[illegible]	1.57	339.	108.2
28	.448	192.	.0412	17.7	7.8	1.52	326.	104.8
29	.527	226.	.0470	20.2	7.6	1.52	344.	102.5
30	.427	184.	.0529	22.7	6.9	2.13	388.	146.1
31	.486	209.	.0303	13.0	6.6	2.09	423.	144.8
32	.499	214.	.0755	32.4	8.3	1.23	423.	149.8
33	.500	215.	.0560	24.1	6.2	1.37	450.	98.7
34	.475	204.	.0446	19.2	5.9	1.23	466.	96.5
35	.502	216.	.0524	22.5	5.9	1.18	476.	80.7
36	.493	212.	.0384	16.5	5.7	.83	485.	36.8
37	.485	208.	.0485	20.8	5.4	.36	506.	24.1
38	.470	202.	.0273	11.7	5.3	.08	507.	3.1
39	.495	213.	.0596	25.6	6.0	.58	461.	91.2
40	.466	200.	.0725	31.1	7.0	3.14	347.	152.9
41	.442	190.	.0598	25.7	6.4	1.08	435.	135.5
42	.541	233.	.0263	11.3	5.9	1.10	470.	92.4
43	.533	229.	.0320	13.7	5.6	.55	445.	46.0
44	.473	203.	.0358	15.4	5.5	.12	498.	16.9
45	.493	212.	.0319	13.7	6.2	1.14	445.	86.4
46	.486	209.	.0463	19.9	4.6	1.75	414.	125.8
47	.502	216.	.0563	24.2	6.7	.96	392.	56.8
48	.425	183.	.0444	19.1	6.3	1.86	433.	125.4
49	.489	210.	.0808	34.7	6.7	1.67	411.	116.3
50	.488	210.	.0214	9.2	5.8	.28	486.	19.4
51	.446	192.	.0388	16.6	5.5	.07	498.	2.5
52	.438	188.	.0219	9.4	6.8	.28	488.	11.3

TABLE 3-1. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
53	.430	185.	.0214	9.2	5.5	.05	409.	2.9
54	.466	200.	.0283	12.1	6.3	.84	418.	74.3
55	.473	203.	.0379	16.3	6.2	1.12	444.	89.5
56	.508	218.	.0472	20.3	5.9	.27	467.	20.9
57	.532	229.	.0480	20.6	5.8	.29	475.	22.1
58	.553	238.	.0752	32.3	7.0	.80	390.	68.2
59	.490	211.	.0801	34.4	6.9	1.49	398.	102.6
60	.490	211.	.0246	10.6	5.7	.11	491.	6.2
61	.502	216.	.0306	13.2	5.7	.06	495.	2.9
62	.468	201.	.0311	13.3	5.6	.12	498.	2.1
63	.476	205.	.0608	26.1	6.3	.93	494.	2.1
64	.466	200.	.0306	13.2	5.7	.08	490.	.0
65	.459	197.	.0336	14.4	5.6	.12	485.	18.2
66	.521	224.	.0687	29.5	6.6	.75	410.	60.5
67	.588	253.	.0195	8.4	6.8	.08	421.	1.8
68	.593	255.	.0204	8.7	6.8	.10	417.	14.3
69	.538	231.	.0788	33.9	7.3	1.07	392.	80.2
70	.491	211.	.0681	29.3	8.1	1.88	333.	133.7
71	.477	205.	.0645	27.7	8.9	1.70	257.	119.6
72	.532	228.	.0780	33.5	8.2	1.95	317.	115.7
73	.515	221.	.0604	26.0	7.4	1.79	370.	131.6
74	.425	183.	.0165	7.1	9.0	.62	192.	37.9
75	.405	174.	.0211	9.0	10.1	.02	175.	.0
76	.483	207.	.0735	31.6	7.2	1.95	381.	141.3
77	.470	202.	.0464	19.9	7.8	1.72	398.	118.4
78	.467	201.	.0947	40.7	8.6	1.97	281.	106.6
79	.410	176.	.0537	23.1	10.0	.08	179.	5.0
80	.484	208.	.0854	36.7	8.2	1.50	308.	103.8
81	.555	239.	.0917	39.4	7.9	.57	314.	20.3
82	.627	269.	.0885	38.0	7.8	.74	330.	47.2
83	.586	252.	.0509	21.9	6.7	.38	415.	35.0
84	.443	190.	.1214	52.1	5.6	3.17	287.	33.5
85	.445	191.	.0545	23.4	6.2	2.63	314.	48.1
86	.510	219.	.0596	25.6	7.5	.64	346.	47.7
87	.506	217.	.0729	31.2	7.1	.50	374.	51.4
88	.468	201.	.0731	31.4	6.9	.49	392.	42.1
89	.422	181.	.0265	11.4	7.3	1.17	365.	82.8
90	.473	203.	.0634	27.2	6.5	.86	426.	68.4
91	.441	190.	.0502	21.6	6.3	1.00	436.	82.8
92	.460	198.	.0908	39.0	5.3	3.81	437.	89.8
93	.575	247.	.1561	67.1	6.4	1.97	326.	96.1
94	.617	265.	.0239	10.3	7.0	.87	399.	88.3

(continued)

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**NO  AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY**

                                LOAD CELL DIMENSIONS
                                        LOWER            UPPER
        CELL NUMBER     CENTER(MW)     BOUNDARY(MW)     BOUNDARY(MW)
        -----------     ----------     ------------     ------------
             1             121.             99.              143.
             2             165.            143.              187.
             3             209.            187.              231.
             4             253.            231.              275.
             5             297.            275.              318.
             6             340.            318.              362.
             7             384.            362.              406.
             8             428.            406.              450.
             9             472.            450.              494.
            10             516.            494.              538.

                              RESULTS OF LOAD SORTING

 CELL    NO. OF     NO  MEAN      NO  MEAN    NO  STD DEV    NO  STD DEV   O2 MEAN   O2 STD DEV   LOAD PROB.
NUMBER  ENTRIES  LB/10**6 BTU      NG/J    LB/10**6 BTU      NG/J      PERCENT    PERCENT      PERCENT
------  -------  ------------  --------  ------------  -----------  -------   ----------   ----------
   1        1         .210          90.        .0000             .0    10.10         .00          .04
   2      398         .421         181.        .0454           19.5     9.92         .76        17.73
   3       87         .514         221.        .0570           24.5     9.35         .75        21.60
   4       83         .475         204.        .0813           34.9     8.42        1.72        25.29
   5      185         .507         218.        .0865           37.2     8.11        1.45        33.51
   6      245         .538         231.        .0855           36.7     7.54         .95        44.40
   7      134         .527         226.        .0901           38.7     6.95        1.05        50.36
   8      351         .541         232.        .0598           25.7     6.58         .44        65.96
   9      321         .475         204.        .0524           22.5     5.85         .83        80.22
  10      444         .474         204.        .0450           19.4     5.53         .53        99.96
```

(continued)

TABLE 3-1. (CONTINUED)

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                              **NO  PROBABILITY**
                              NO  CELL DIMENSIONS

                                               LOWER                      UPPER
 CELL            CENTER                       BOUNDARY                   BOUNDARY
NUMBER      LB/10**6 BTU   NG/J        LB/10**6 BTU   NG/J        LB/10**6 BTU   NG/J
======      ============   ====        ============   ====        ============   ====
  1             .187         80.           .155         67.           .219         94.
  2             .251        108.           .219         94.           .283        122.
  3             .315        135.           .283        122.           .347        149.
  4             .379        163.           .347        149.           .411        177.
  5             .443        190.           .411        177.           .475        204.
  6             .507        218.           .475        204.           .539        232.
  7             .571        245.           .539        232.           .603        259.
  8             .635        273.           .603        259.           .667        287.
  9             .699        300.           .667        287.           .731        314.
 10             .763        328.           .731        314.           .795        342.

                             NO  PROBABILITY RESULTS

                                             CUM. PROB.
             CELL          NUMBER OF          PERCENT
            NUMBER          ENTRIES          LESS THAN
            ======         =========         ==========
              1                3                .13
              2                0                .13
              3               12                .67
              4              329              15.29
              5              714              47.02
              6              617              74.44
              7              416              92.93
              8              119              98.22
              9               31              99.60
             10                8              99.96
```

(continued)

TABLE 3-1. (CONTINUED)

```
                    **NOX COMPLIANCE WITH RESPECT TO 1971 NSPS**
      FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
         FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)
      FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)
                    THIS BOILER WAS OPERATED WITH SUBBITUMINOUS COAL
      THE NOX MEASURED DURING THE PERFORMANCE TEST WAS   .503  LB/10**6 BTU (216. NG/J)
AN ANALYSIS OF 3-HOUR NO  ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
            INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON    17  OCCASIONS
AN ANALYSIS OF 3-HOUR NO  BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
            INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     6  OCCASIONS
```

(continued)

TABLE 3-1. (CONTINUED)

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              **NOX COMPLIANCE WITH RESPECT TO 1978 NSPS**

                  1978 NSPS NOX EMISSION LIMITATIONS
          SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
            BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
  LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
            OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)

   ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED     0  EXCEEDANCES

                      30-DAY ROLLING AVERAGES
            EMISSION LIMITATION  .50 LB/10**6 BTU  215. NG/J

              SEQUENTIAL          30-DAY AVERAGE NO
               AVERAGE            LB/10**6 BTU  NG/J
              ----------          ------------  ----
                   1                  .484      208.
                   2                  .487      209.
                   3                  .491      211.
                   4                  .492      211.
                   5                  .495      213.
                   6                  .498      214.
                   7                  .498      214.
                   8                  .499      214.
                   9                  .497      214.
                  10                  .499      214.
                  11                  .498      214.
                  12                  .495      213.
                  13                  .498      214.
                  14                  .502      216.
                  15                  .499      214.
                  16                  .496      213.
                  17                  .491      211.
                  18                  .489      210.
                  19                  .487      209.
                  20                  .487      209.
                  21                  .486      209.
                  22                  .483      207.
                  23                  .481      207.
                  24                  .480      206.
                  25                  .479      206.
                  26                  .479      206.
                  27                  .480      206.
                  28                  .481      207.
                  29                  .485      208.
                  30                  .484      208.
                  31                  .486      209.
                  32                  .486      209.
                  33                  .485      209.
                  34                  .485      208.
                  35                  .484      208.
                  36                  .483      207.
                  37                  .484      208.
                  38                  .487      209.
                  39                  .491      211.
                  40                  .493      212.
                  41                  .494      212.
                  42                  .495      213.
                  43                  .494      212.
                  44                  .494      212.
                  45                  .492      211.
                  46                  .489      210.
                  47                  .489      210.
                  48                  .488      210.
                  49                  .489      210.
                  50                  .487      209.
                  51                  .487      209.
                  52                  .490      211.
                  53                  .497      213.
                  54                  .502      216.
                  55                  .501      215.
                  56                  .500      215.
                  57                  .500      215.
                  58                  .499      214.
                  59                  .496      213.
                  60                  .494      212.
                  61                  .494      212.
                  62                  .492      211.
                  63                  .491      211.
                  64                  .495      212.
                  65                  .500      215.
```

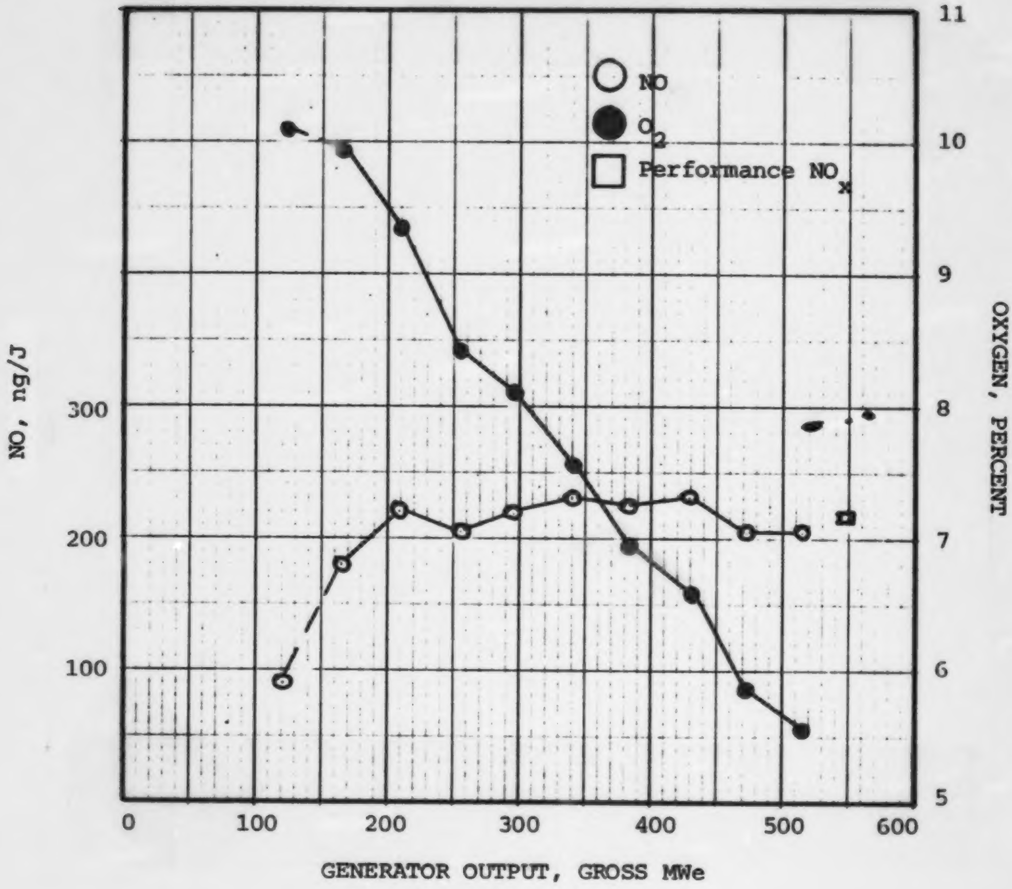

Figure 3-1. Muskogee Unit 4 - Boiler Characteristics

3-2,

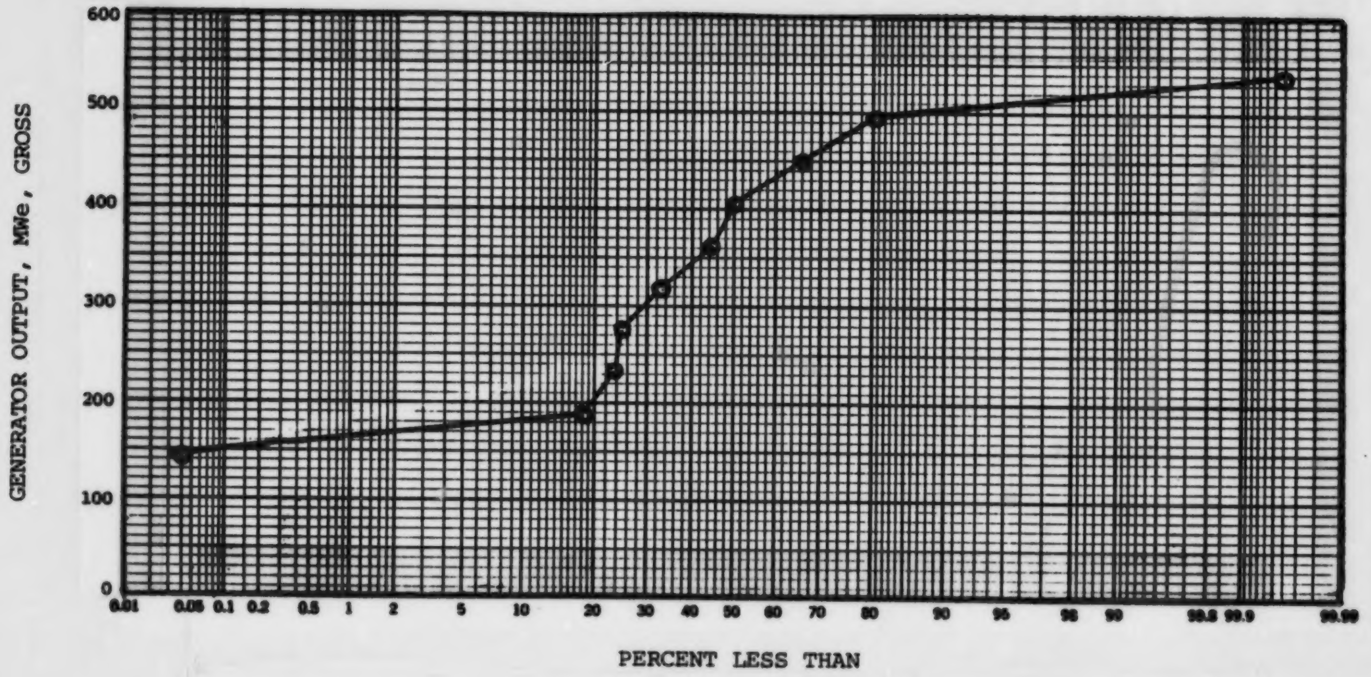

Figure 3-2. Muskogee Unit 4 - Load Probability

3-3.

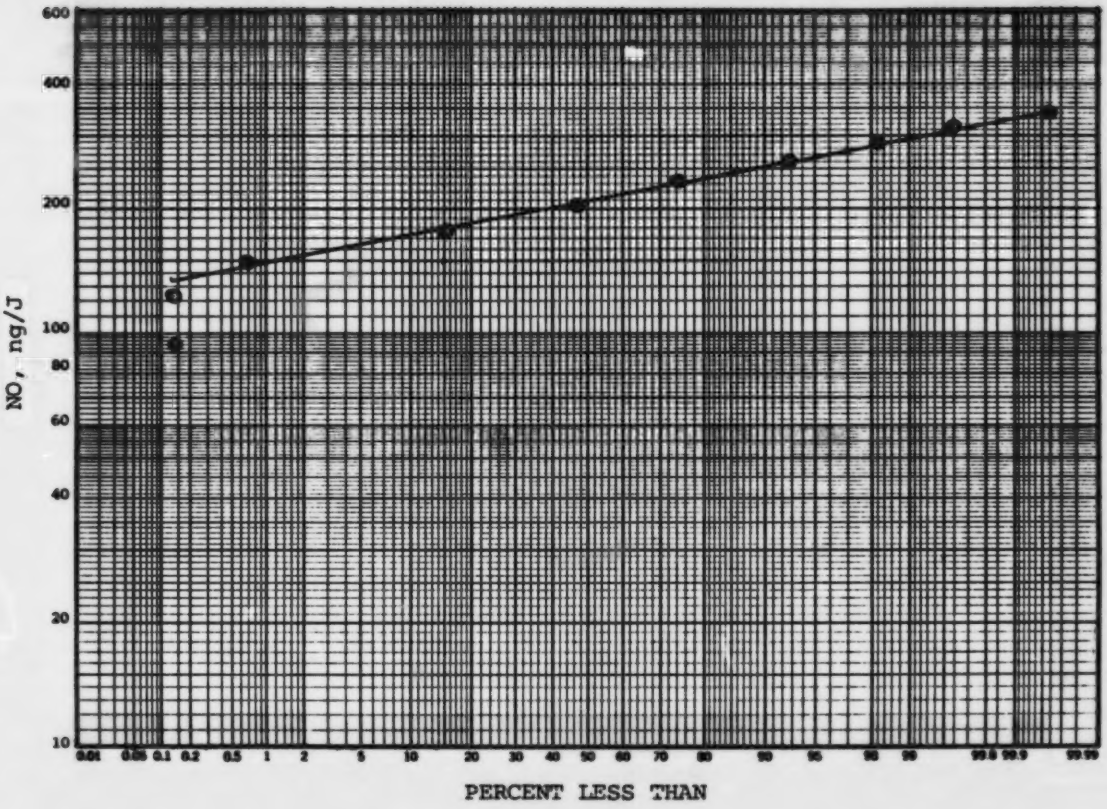

Figure 3-3. Muskogee Unit 4 - NO Probability

3-4.

TABLE 3-2. INITIAL COMPUTER ANALYSIS - MUSKOGEE UNIT 5

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 **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**

DATA SUBMITTED BY OKLAHOMA GAS AND ELECTRIC

MUSKOGEE STATION UNIT 5  SUBBITUMINOUS COAL  MON. REL. ACC. = 18.2 PC

DAY 1 IS OCTOBER 15, 1980     DAY 94 IS JANUARY 16, 1981

550 MWE, COMBUSTION ENGINEERING BOILER WITH OVERFIRE AIR

COAL PROPERTIES IDENTICAL TO UNIT 4

BOILER OFF-LINE FROM DEC. 13, 1980 TO DEC. 24, 1980 INCLUSIVE
```

(continued)

TABLE 3-2. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
1	.262	112.	.1397	60.0	6.1	2.90	343.	99.0
2	.268	115.	.0846	36.4	5.3	2.88	399.	118.2
3	.488	210.	.0826	35.5	9.2	.84	255.	97.5
4	.489	210.	.0500	21.5	9.2	.79	261.	72.8
5	.481	207.	.0126	5.4	10.0	.00	180.	.3
6	.498	214.	.0262	11.3	9.1	.75	267.	68.2
7	.507	218.	.0420	18.1	9.0	.80	278.	66.1
8	.500	215.	.0503	21.6	9.0	.58	255.	46.7
9	.485	209.	.0611	26.2	9.0	.99	279.	76.6
10	.504	217.	.0451	19.4	8.3	1.53	324.	105.7
11	.557	239.	.0538	23.1	9.1	1.21	270.	90.8
12	.518	223.	.0550	23.6	9.3	.69	251.	90.0
13	.430	185.	.0877	37.7	7.3	1.07	371.	124.0
14	.325	140.	.0604	26.0	6.9	1.00	302.	65.6
15	.281	121.	.0301	12.9	6.6	.89	393.	65.7
16	.406	174.	.0663	28.5	8.4	.59	275.	52.7
17	.407	175.	.0458	19.7	8.5	1.28	264.	82.9
18	.437	188.	.0279	12.0	9.6	.29	203.	17.0
19	.377	162.	.0358	15.4	9.1	.75	219.	35.3
20	.394	169.	.0147	6.3	9.1	.91	227.	27.0
21	.330	142.	.0621	26.7	7.8	1.75	303.	111.6
22	.295	127.	.0470	20.2	7.1	1.45	304.	93.4
23	.357	153.	.0813	34.9	7.0	1.76	313.	99.7
24	.385	166.	.1240	53.3	7.3	2.06	337.	129.6
25	.442	190.	.1621	69.7	8.9	1.24	224.	76.3
26	.519	223.	.0951	40.9	9.2	.83	208.	35.9
27	.417	179.	.1225	52.6	6.9	2.08	338.	113.2
28	.388	167.	.1336	57.4	6.4	2.53	388.	149.7
29	.385	166.	.1249	53.7	5.9	2.51	401.	139.9
30	.337	145.	.1172	50.4	6.9	2.27	392.	127.7
31	.375	161.	.1122	48.2	6.8	2.30	398.	133.1
32	.332	143.	.0660	28.4	7.2	1.43	292.	73.4
33	.282	121.	.0500	21.5	6.9	1.57	437.	92.6
34	.286	123.	.0819	35.2	5.3	2.28	419.	119.7
35	.318	137.	.0887	38.1	5.3	1.86	452.	69.7
36	.438	188.	.0355	15.3	6.3	.20	448.	9.7
37	.403	173.	.0244	10.5	6.3	.40	440.	20.4
38	.375	161.	.0224	9.6	6.2	.45	449.	1.0
39	.412	177.	.0216	9.3	6.4	.42	428.	50.4
40	.433	186.	.1302	55.9	7.5	1.01	347.	123.5
41	.394	169.	.0611	26.3	6.8	1.44	401.	111.2
42	.404	174.	.0671	28.8	7.1	1.53	393.	89.3
43	.378	162.	.0733	31.5	6.7	1.51	422.	88.8
44	.352	151.	.0214	9.2	6.1	.11	452.	3.0
45	.397	171.	.0450	19.3	7.9	1.02	358.	65.3
46	.385	166.	.0744	32.0	7.7	1.78	352.	117.0
47	.412	177.	.0689	29.6	8.1	.90	326.	61.5
48	.332	143.	.0755	32.4	6.9	1.42	396.	107.9
49	.365	157.	.0102	4.4	6.2	.11	451.	2.1
50	.394	169.	.0223	9.6	6.3	.00	450.	2.3
51	.370	159.	.0393	16.9	6.2	.00	449.	2.3
52	.293	126.	.0163	7.0	6.1	.00	443.	[illegible]
53	.300	129.	.0144	6.2	6.2	.07	440.	34.9
54	.366	157.	.0355	15.2	7.0	1.20	345.	75.3
55	.397	171.	.0189	8.1	6.6	.87	422.	59.8
56	.380	163.	.0268	11.5	6.3	.27	440.	17.9
57	.415	178.	.0411	17.6	6.3	.22	443.	13.5
58	.337	145.	.0828	35.6	7.3	1.12	370.	67.8
59	.356	153.	.0878	37.7	7.3	1.24	359.	112.1
72	.284	122.	.0620	26.6	10.2	1.09	138.	7.5
73	.275	118.	.0390	16.8	10.0	.00	135.	1.5
74	.285	122.	.0260	11.2	10.0	.00	134.	.5
75	.284	122.	.0171	7.4	10.0	.00	135.	.8
76	.338	145.	.0807	34.7	9.2	1.51	204.	116.0
77	.412	177.	.1503	64.6	8.0	1.65	403.	93.6
78	.572	246.	.1323	56.8	8.9	1.50	264.	102.9
79	.638	274.	.0268	11.5	10.0	.00	181.	13.6
80	.577	248.	.0851	36.6	8.4	1.61	307.	103.5
81	.551	237.	.0664	28.5	8.1	.49	313.	31.2
82	.555	238.	.1200	51.6	7.9	.74	338.	44.3
83	.485	209.	.0834	35.9	6.7	.80	405.	32.6
84	.623	268.	.0584	25.1	8.7	.64	286.	33.5
85	.599	257.	.0416	17.9	8.5	.57	303.	32.7
86	.595	256.	.0361	15.5	8.1	.56	315.	30.4
87	.582	250.	.0451	19.4	7.3	.45	353.	29.0
88	.620	267.	.1026	44.1	7.3	.97	365.	53.0
89	.627	270.	.1185	50.9	8.5	.88	301.	45.5
90	.542	233.	.0524	22.5	6.6	.83	419.	98.6
91	.535	230.	.0388	16.7	6.8	.91	409.	99.0
92	.522	224.	.0962	41.3	7.5	1.63	368.	113.0
93	.538	231.	.0886	38.1	8.2	1.28	314.	90.0
94	.514	221.	.1155	49.6	6.8	1.17	415.	75.0

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TABLE 3-2. (CONTINUED)

NO AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

	LOAD CELL DIMENSIONS		
CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	52.	27.	77.
2	102.	77.	127.
3	152.	127.	177.
4	202.	177.	227.
5	252.	227.	276.
6	301.	276.	326.
7	351.	326.	376.
8	401.	376.	426.
9	451.	426.	476.
10	501.	476.	526.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO. MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD PROB. PERCENT
1	1	.020	9.	.0000	.0	10.00	.00	.05
2	4	.187	81.	.0802	34.4	9.80	.40	.26
3	180	.402	173.	.1591	68.4	10.03	.38	9.48
4	280	.509	219.	.0815	35.0	9.85	.33	23.83
5	170	.500	215.	.1342	57.7	8.93	.62	32.55
6	247	.482	207.	.1242	53.3	8.22	.63	45.21
7	208	.459	197.	.1049	45.1	7.55	.80	55.87
8	131	.385	165.	.1276	54.8	6.30	.92	62.58
9	613	.371	159.	.0700	30.1	6.08	.43	94.00
10	116	.277	119.	.0440	18.9	4.22	.73	99.95

(continued)

TABLE 3-2.   (CONTINUED)

```
                                   **NO  PROBABILITY**

                                  NO  CELL DIMENSIONS

                                                  LOWER                        UPPER
  CELL          CENTER                           BOUNDARY                     BOUNDARY
 NUMBER    LB/10**6 BTU   NG/J          LB/10**6 BTU   NG/J         LB/10**6 BTU   NG/J
 ------    ------------   ----          ------------   ----         ------------   ----
    1          .056        24.              .015         6.             .096        41.
    2          .136        59.              .096        41.             .177        76.
    3          .217        93.              .177        76.             .258       111.
    4          .298       128.              .258       111.             .339       146.
    5          .379       163.              .339       146.             .420       180.
    6          .460       198.              .420       180.             .501       215.
    7          .541       233.              .501       215.             .582       250.
    8          .622       267.              .582       250.             .663       285.
    9          .703       302.              .663       285.             .744       320.
   10          .784       337.              .744       320.             .825       354.

                                  NO  PROBABILITY RESULTS

                                                         CUM. PROB.
                   CELL              NUMBER OF            PERCENT
                  NUMBER              ENTRIES            LESS THAN
                  ------             ---------           ----------
                     1                   1                    .05
                     2                  19                   1.03
                     3                  82                   5.23
                     4                 410                  26.24
                     5                 510                  52.38
                     6                 419                  73.86
                     7                 250                  86.67
                     8                 201                  96.98
                     9                  48                  99.44
                    10                  10                  99.95
```

(continued)

TABLE 3-2. (CONTINUED)

NOX COMPLIANCE WITH RESPECT TO 1971 NSPS

FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)

FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)

FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)

FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)

THIS BOILER WAS OPERATED WITH SUBBITUMINOUS COAL

THE NOX MEASURED DURING THE PERFORMANCE TEST WAS .624 LB/10**6 BTU (268. NG/J)

AN ANALYSIS OF 3-HOUR NO ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)

INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON 16 OCCASIONS

AN ANALYSIS OF 3-HOUR NO BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)

INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON 6 OCCASIONS

(continued)

TABLE 3-2. (CONTINUED)

```
                **NOX COMPLIANCE WITH RESPECT TO 1978 NSPS**

                     1978 NSPS NOX EMISSION LIMITATIONS
             SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
               BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
     LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
               OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)


       ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED     0  EXCEEDANCES

                          30-DAY ROLLING AVERAGES
            EMISSION LIMITATION  .50 LB/10**6 BTU  215. NG/J

                 SEQUENTIAL           30-DAY AVERAGE NO
                  AVERAGE             LB/10**6 BTU  NG/J
                 ----------           ------------  ----
                     1                    .416      179.
                     2                    .420      180.
                     3                    .422      181.
                     4                    .415      178.
                     5                    .408      175.
                     6                    .403      173.
                     7                    .401      172.
                     8                    .397      171.
                     9                    .393      169.
                    10                    .391      168.
                    11                    .388      167.
                    12                    .383      164.
                    13                    .379      163.
                    14                    .377      162.
                    15                    .378      162.
                    16                    .382      164.
                    17                    .381      164.
                    18                    .381      164.
                    19                    .378      162.
                    20                    .378      162.
                    21                    .377      162.
                    22                    .379      163.
                    23                    .379      163.
                    24                    .377      162.
                    25                    .376      162.
                    26                    .375      161.
                    27                    .370      159.
                    28                    .370      159.
                    29                    .368      158.
                    30                    .367      158.
                    31                    .365      157.
                    32                    .362      156.
                    33                    .360      155.
                    34                    .361      155.
                    35                    .362      156.
                    36                    .365      157.
                    37                    .370      159.
                    38                    .378      162.
                    39                    .384      165.
                    40                    .389      167.
                    41                    .393      169.
                    42                    .396      170.
                    43                    .404      173.
                    44                    .411      177.
                    45                    .419      180.
                    46                    .425      183.
                    47                    .433      186.
                    48                    .440      189.
                    49                    .447      192.
                    50                    .453      195.
                    51                    .457      196.
                    52                    .463      199.
                    53                    .470      202.
```

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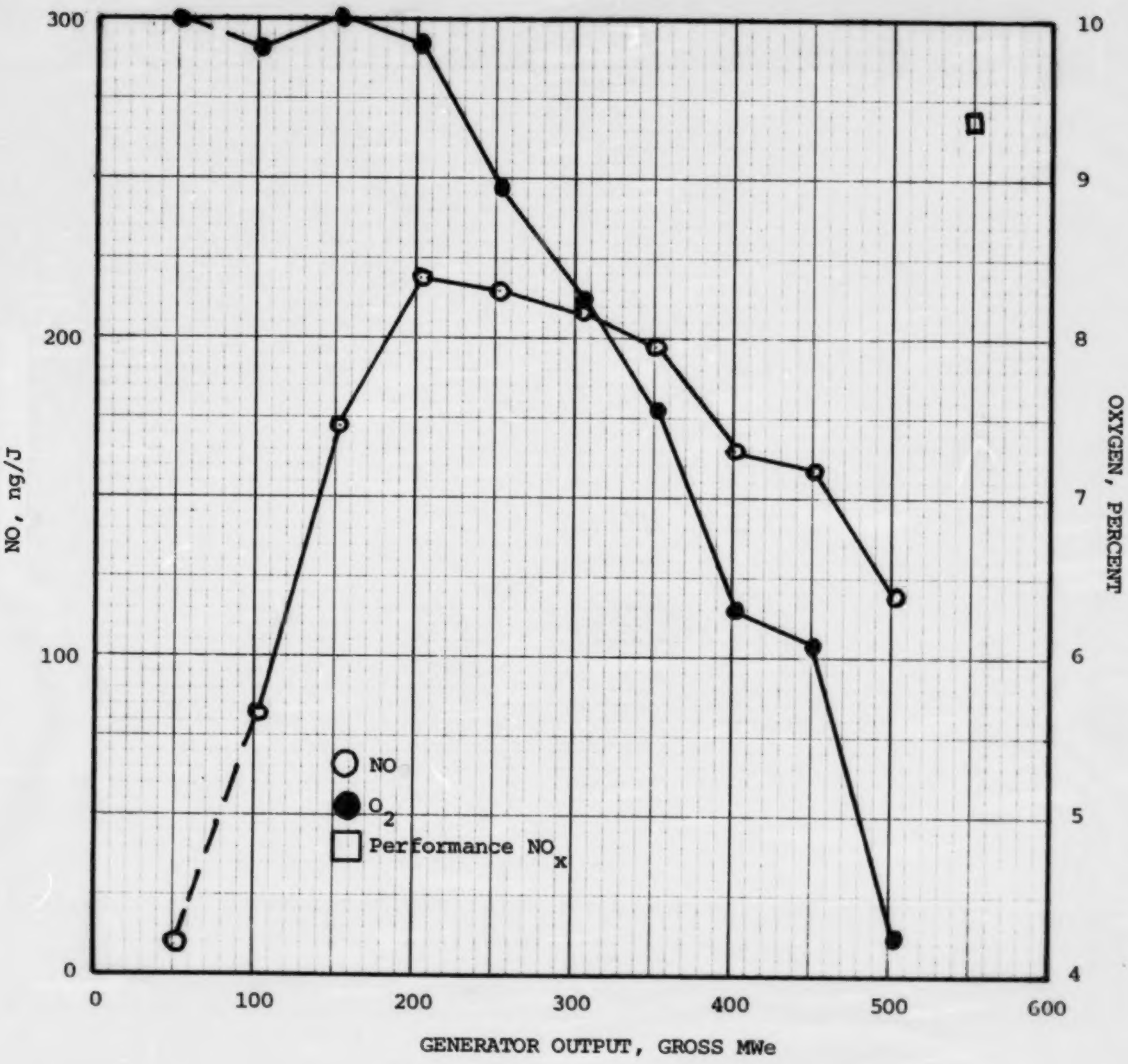

Figure 3-4. Muskogee Unit 5 - Boiler Characteristics

3-6,

unexplained. The median load (Figure 3-5) is 350 gross MWe which is about 63.6 percent of rating. The NO probability is representable in normal coordinates (Figure 3-6) with a mean of 193 ng/J and a standard deviation of 49 ng/J.

Figures 3-7 and 3-8 compare the NO and O_2 boiler characteristics of Units 4 and 5. The marked difference in NO is noted for loads above 300 gross MWe (54.5 percent of rating). A portion of this difference could be attributed to the lower O_2 of Unit 5, however, this does not occur until the load exceeds 450 gross MWe (81.8 percent of rating).

An examination of the analysis results with respect to the 1978 NSPS indicates that Unit 4 would have met the performance test and would not have had any periods of excess NO emissions. This last statement must be qualified since the monitor is measuring NO only and not total NO_x ($NO + NO_2$). If the NO_2 component had been included on the basis of it comprising 3 percent of total NO_x (Reference 1) then there would have been periods of excess emissions, i.e., Unit 4's margin with respect to the 1978 NSPS would have been slight. This margin, at most, would have been 9 ng/J (0.02 lb/10^6 Btu) without the inclusion of the estimated NO_2 component.

Unit 5 would also have met the 1978 NSPS performance test and would have had no periods of excess emissions even if NO_2 had added 3 percent to the measured NO. However, the entire subject of Unit 5's NO characteristics at high-load is still unresolved.

The computer analysis was repeated as a result of the site visit. The revised analyses deleted those hourly-averaged data whose validity was questionable. This entailed deleting 463 and 1,494 data points for Units 4 and 5, respectively, with Figures 3-9 and 3-10 showing the difference in NO and O_2 versus load between the initial and revised analyses for Unit 5. As noted, Unit 5's mid-load range NO increased and still showed a steep drop-off in NO with load. Unit 4's NO and O_2 characteristics remained essentially unchanged. (Tables 3-3 and 3-4 are the computer summaries for the revised analyses.)

(text continued on page 3-37)

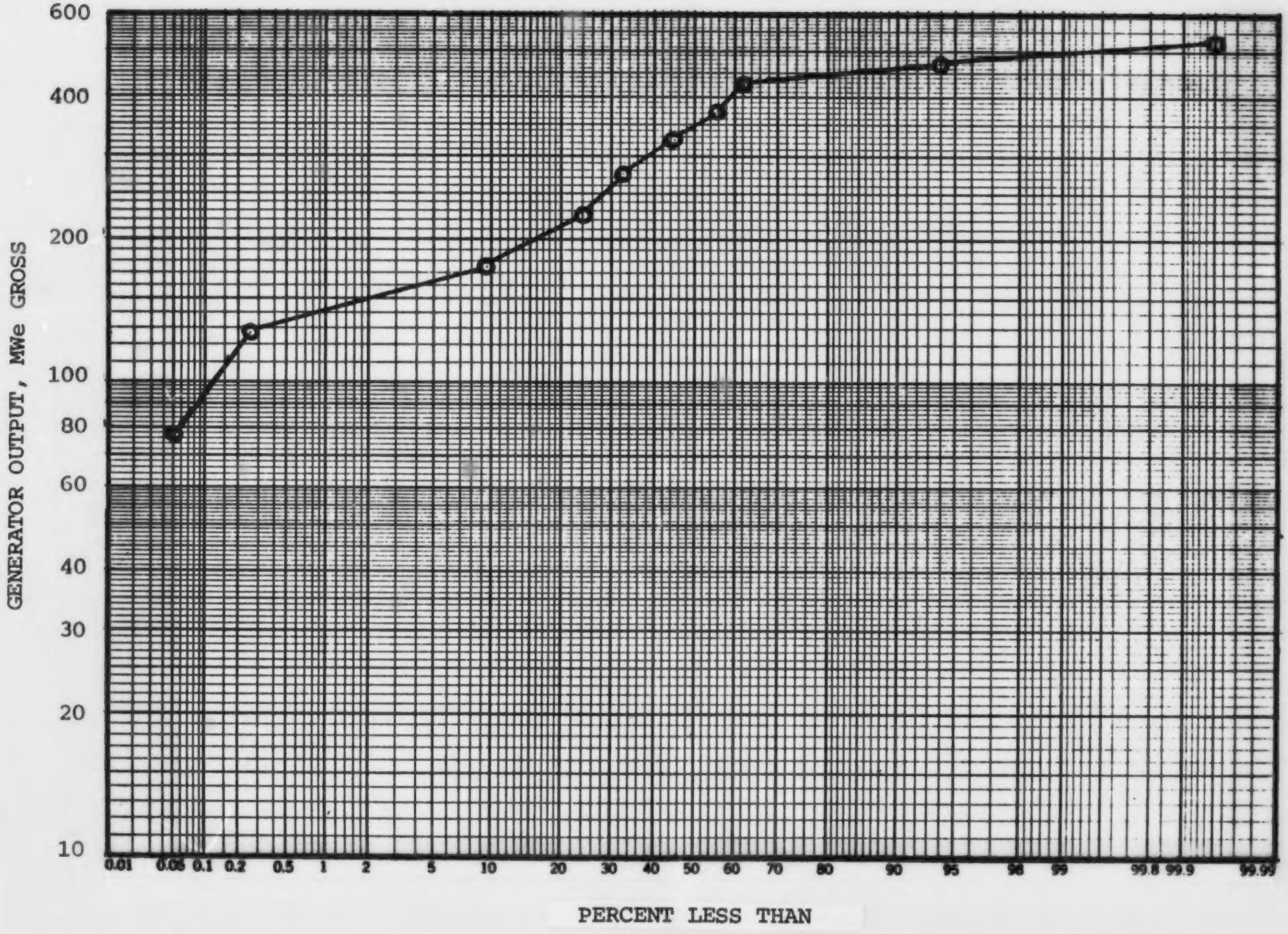

Figure 3-5. Muskogee Unit 5 - Load Probability

3-7,

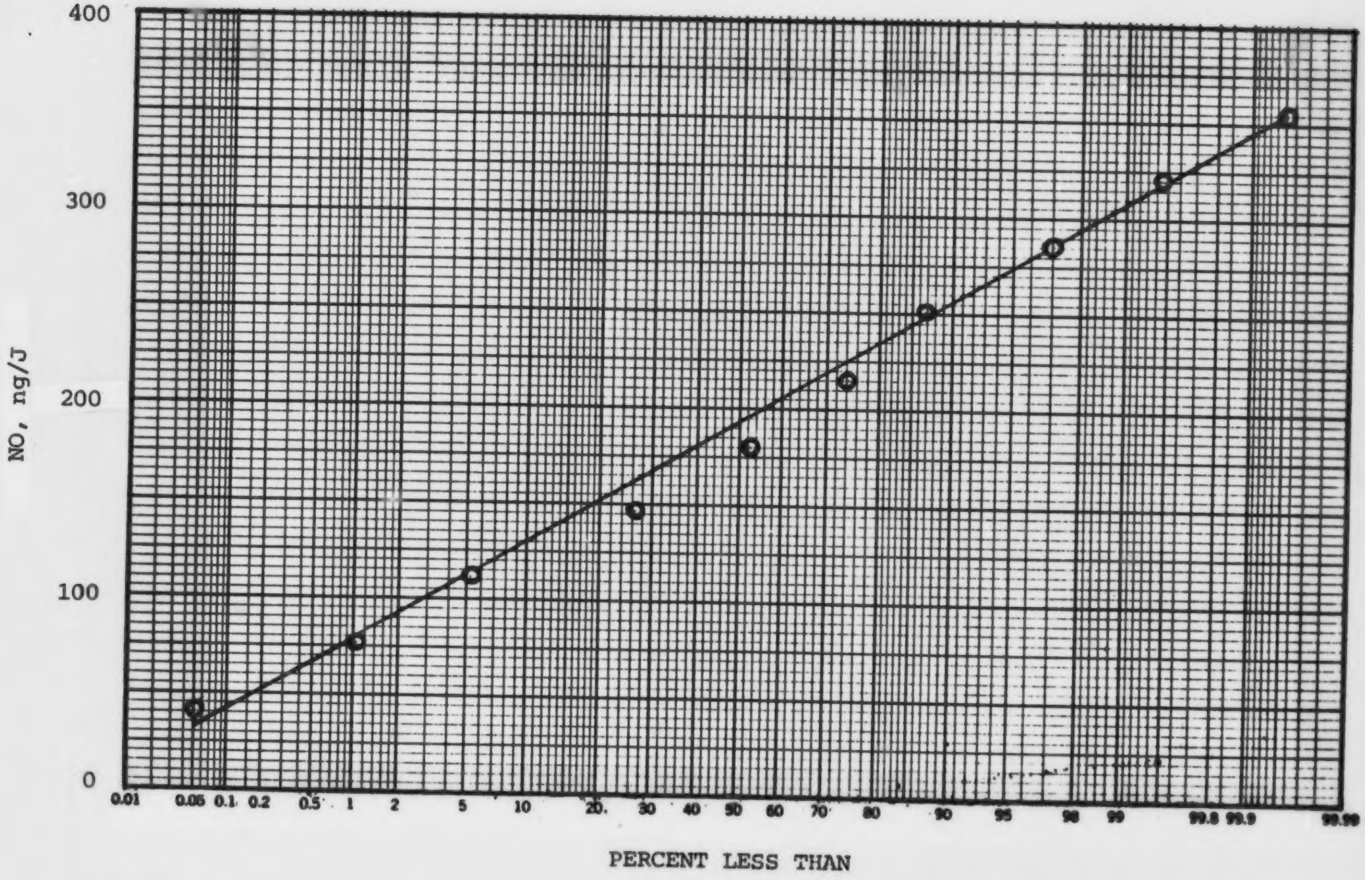

Figure 3-6. Muskogee Unit 5 - NO Probability

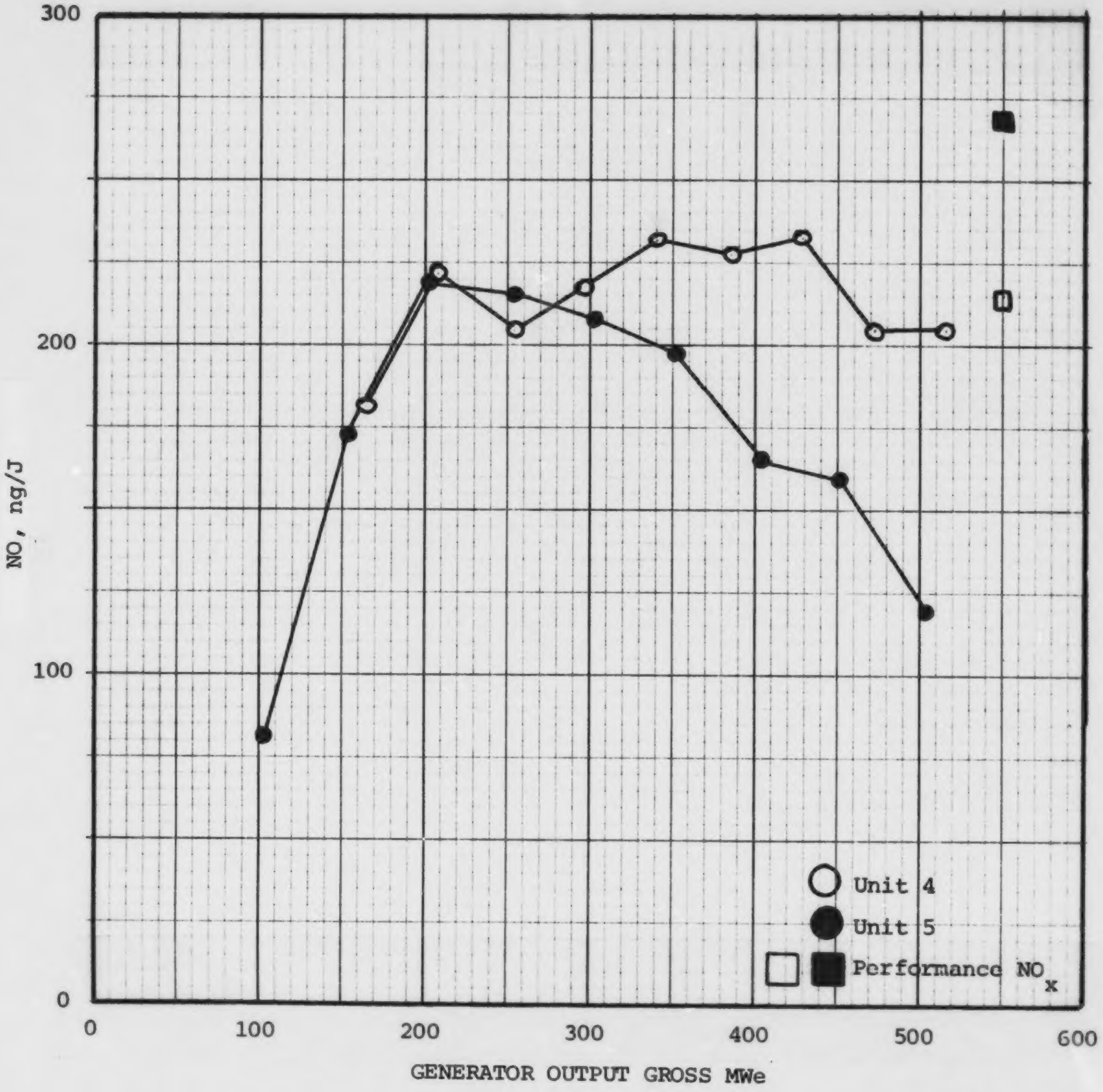

Figure 3-7. Muskogee Units 4 and 5 - Comparison of NO Characteristic

3-7

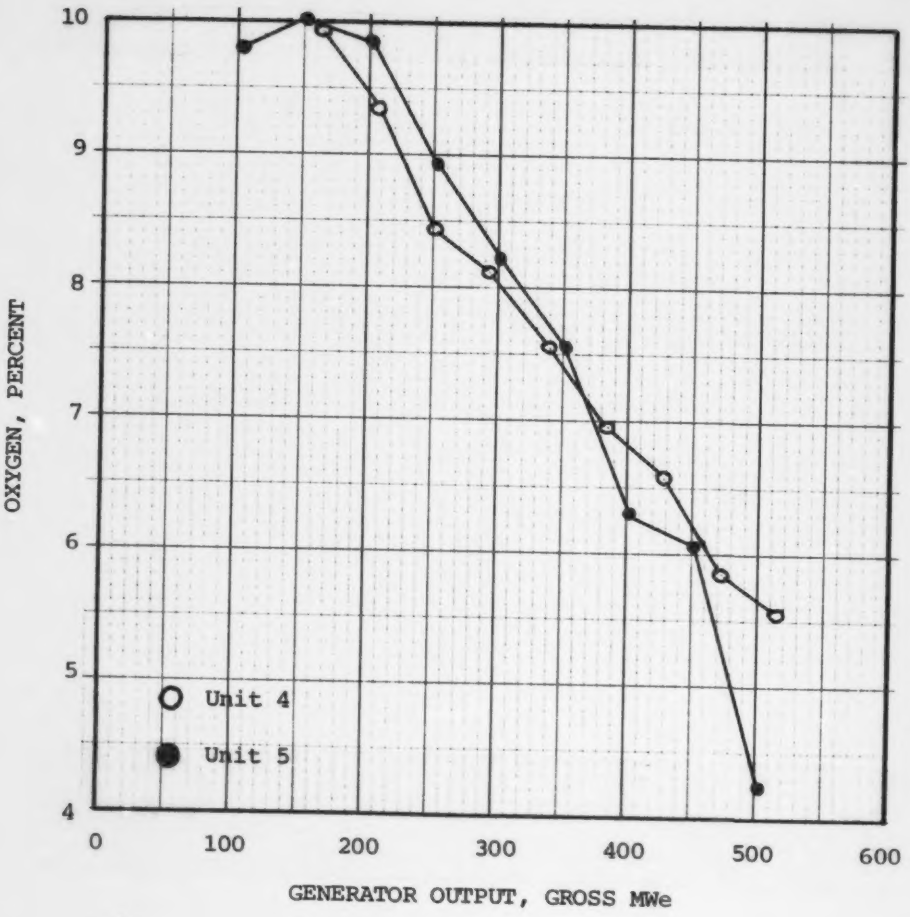

Figure 3-8. Muskogee Units 4 and 5 - Comparison of O_2 Characteristic

3-10

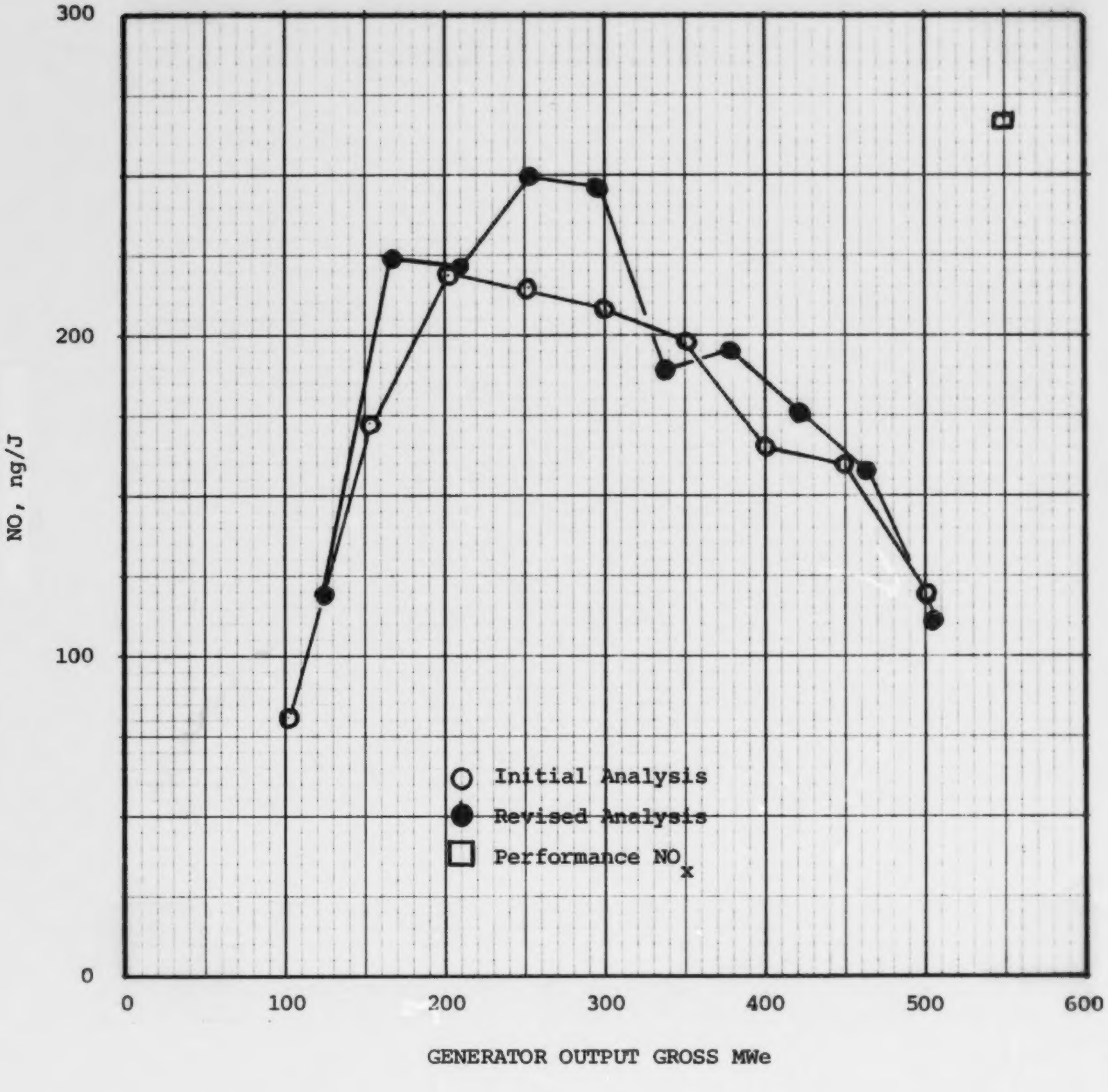

Figure 3-9. Muskogee Unit 5 - Comparison of NO Characteristic

3-11

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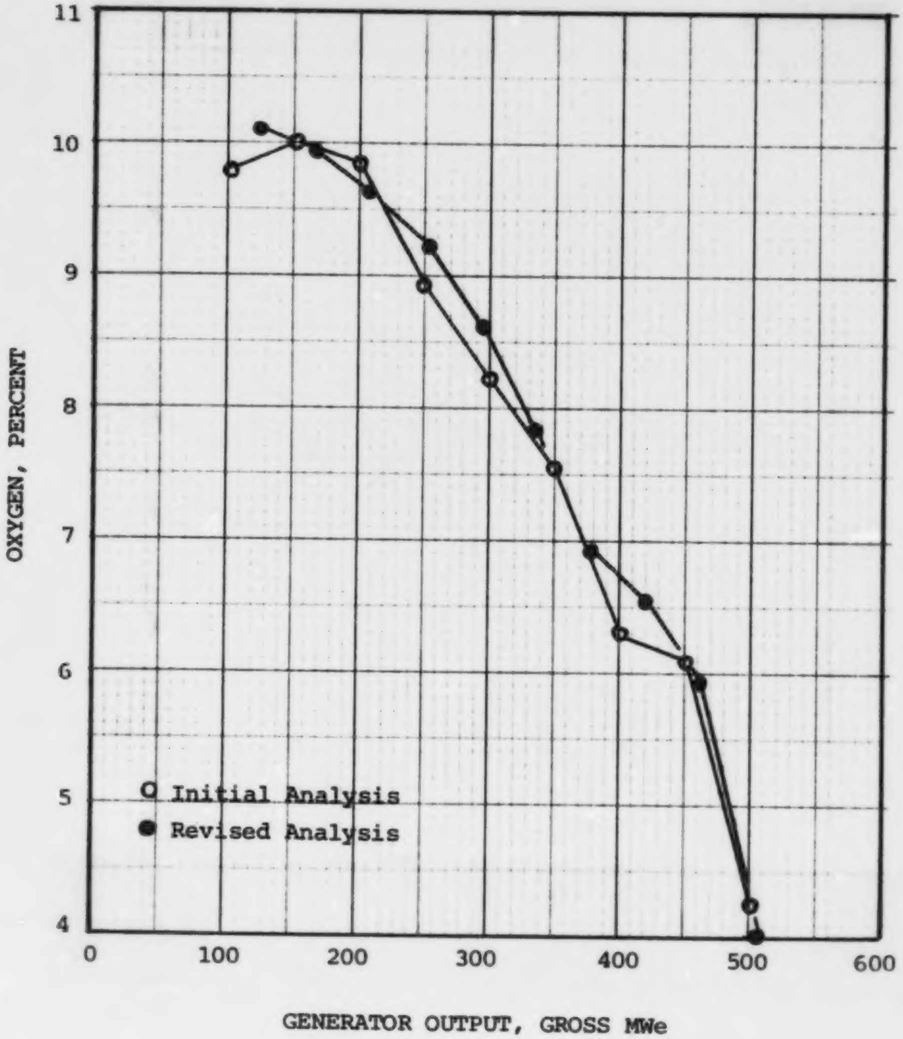


Figure 3-10. Muskogee Unit 5 - Comparison of O_2 Characteristic

3-12

TABLE 3-3. REVISED COMPUTER ANALYSES - MUSKOGEE UNIT 4

```
                         **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
DATA SUBMITTED BY OKLAHOMA GAS AND ELECTRIC MUSKOGEE STATION
UNIT 4    SUBBITUMINOUS COAL  NO  MON. REL. ACC. = 10.9 PC
DAY 1 IS OCTOBER 15, 1980     DAY 94 IS JANUARY 16, 1981
550 MWE, COMBUSTION ENGINEERING BOILER WITH OVERFIRE AIR
COAL PROXIMATE 8815+-57BTU/LB, 0.337+-0.037 PC SULFUR,
             4.86+-0.371 PC ASH, 27.73+-0.36 PC MOISTURE
```

(continued)

TABLE 3-3. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
1	.390	171.	.0624	26.8	9.0	.47	189.	27.0
2	.385	165.	.0269	11.5	9.9	.09	100.	.0
3	.466	200.	.0589	25.3	9.8	.87	249.	97.7
4	.388	167.	.0334	14.3	10.0	.40	181.	3.1
7	.463	199.	.0338	14.5	8.8	1.01	286.	66.2
8	.507	218.	.0464	19.9	9.1	.61	252.	47.1
9	.454	195.	.0488	21.0	8.7	1.11	272.	74.7
10	.493	212.	.0253	10.9	9.4	.66	231.	89.8
11	.517	222.	.0531	22.8	9.1	1.20	205.	80.9
12	.446	192.	.0204	8.8	9.3	.71	243.	52.9
13	.436	187.	.0239	10.3	7.9	1.58	345.	107.0
16	.642	276.	.0843	36.2	7.5	.51	355.	40.3
17	.562	241.	.0677	29.1	7.7	1.10	350.	84.2
18	.482	207.	.0506	21.7	9.4	.51	228.	39.4
19	.476	205.	.0468	20.1	9.3	.63	233.	40.7
20	.530	228.	.0692	29.7	7.5	1.40	363.	101.3
21	.534	229.	.0659	28.3	7.2	1.26	371.	91.1
22	.487	209.	.0594	25.5	7.6	.86	340.	67.1
23	.473	203.	.0595	25.5	8.1	1.41	302.	94.5
24	.485	208.	.0527	22.7	7.9	1.56	312.	106.7
25	.483	208.	.0775	33.3	8.5	1.41	269.	90.0
26	.457	196.	.0657	28.2	9.7	.50	199.	35.2
29	.526	226.	.0469	20.2	7.8	1.60	339.	100.6
30	.426	183.	.0545	23.4	7.1	2.16	376.	107.0
31	.486	209.	.0303	13.0	6.6	2.04	423.	109.0
32	.500	215.	.0786	33.8	8.4	1.23	415.	154.2
35	.508	218.	.0488	21.0	5.7	1.08	491.	70.5
36	.494	212.	.0401	17.2	5.8	.40	480.	30.0
37	.485	208.	.0485	20.8	5.4	.36	506.	20.1
38	.470	202.	.0273	11.7	5.3	.08	507.	3.1
39	.495	213.	.0596	25.6	6.0	.50	441.	51.2
40	.466	200.	.0723	31.1	7.0	2.14	387.	152.0
41	.424	182.	.0420	18.0	6.7	2.11	422.	105.1
43	.533	229.	.0320	13.7	5.6	.53	495.	40.0
44	.480	206.	.0365	15.7	5.5	.13	497.	19.3
45	.495	212.	.0333	14.3	6.2	1.17	440.	80.7
46	.486	209.	.0463	19.9	6.6	1.75	410.	125.0
47	.505	217.	.0612	26.3	6.5	.44	407.	50.0
49	.480	206.	.0804	34.5	6.6	1.58	415.	121.1
50	.488	210.	.0214	9.2	5.8	.24	446.	19.4
55	.473	203.	.0359	15.4	6.0	1.06	457.	81.1
56	.508	218.	.0472	20.3	5.9	.27	467.	20.9
57	.532	229.	.0480	20.6	5.9	.24	475.	22.1
58	.553	238.	.0752	32.3	7.0	.80	390.	68.2
59	.485	209.	.0820	35.2	6.7	1.27	412.	94.5
60	.490	211.	.0246	10.6	5.7	.11	491.	6.2
61	.502	216.	.0306	13.2	5.7	.06	495.	2.9
62	.468	201.	.0311	13.3	5.6	.12	494.	2.1
63	.476	205.	.0608	26.1	6.3	.93	494.	2.1
64	.466	200.	.0306	13.2	5.7	.08	490.	.0
65	.460	198.	.0349	15.0	5.7	.11	485.	19.0
66	.521	224.	.0687	29.5	6.6	.75	418.	60.5
68	.593	255.	.0204	8.7	6.8	.10	417.	18.3
69	.538	231.	.0788	33.9	7.3	1.07	392.	80.3
70	.491	211.	.0681	29.3	8.1	1.80	333.	133.7
71	.474	203.	.0664	28.5	8.8	1.74	260.	122.7
73	.515	221.	.0604	26.0	7.4	1.70	370.	131.6
74	.425	183.	.0164	7.1	9.8	.62	192.	37.9
75	.397	171.	.0129	5.6	10.1	.02	175.	.0
76	.483	207.	.0735	31.6	7.2	1.95	381.	141.3
77	.470	202.	.0464	19.9	7.8	1.72	396.	110.4
78	.475	204.	.0979	42.1	8.4	1.69	381.	114.0
79	.413	177.	.0550	23.6	10.0	.08	180.	5.0
80	.488	209.	.0854	36.7	8.2	1.50	308.	103.0
81	.555	239.	.0917	39.4	7.9	.37	314.	20.3
82	.627	269.	.0885	38.0	7.8	.74	330.	47.2
83	.586	252.	.0509	21.9	6.7	.38	415.	35.0
84	.460	198.	.1108	47.6	5.9	3.10	291.	32.2
85	.445	191.	.0545	23.4	6.2	2.63	314.	40.1
86	.510	219.	.0596	25.6	7.5	.64	346.	47.7
87	.512	220.	.0712	30.6	7.1	.59	368.	49.0
88	.468	201.	.0731	31.4	6.9	.48	392.	42.1
89	.422	181.	.0265	11.4	7.3	1.17	365.	82.0
90	.470	202.	.0645	27.7	6.6	.87	420.	60.0
91	.441	190.	.0502	21.6	6.3	1.08	430.	82.0
92	.465	200.	.0907	39.0	5.5	3.77	439.	85.0
93	.575	247.	.1561	67.1	6.8	1.97	326.	96.1
94	.617	265.	.0426	18.3	7.0	.47	300.	80.3

(continued)

TABLE 3-3. (CONTINUED)

NO AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	121.	99.	143.
2	165.	143.	187.
3	209.	187.	231.
4	253.	231.	275.
5	297.	275.	318.
6	340.	318.	362.
7	384.	362.	406.
8	428.	406.	450.
9	472.	450.	494.
10	516.	494.	538.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD PROB. PERCENT
1	1	.210	90.	.0000	.0	10.10	.00	.06
2	331	.418	180.	.0453	19.5	9.90	.84	18.58
3	77	.518	223.	.0580	24.9	9.33	.79	22.89
4	73	.479	206.	.0745	32.0	8.55	1.47	26.97
5	135	.499	214.	.0890	38.2	8.05	1.66	34.53
6	193	.534	229.	.0909	39.0	7.49	1.05	45.33
7	118	.529	227.	.0899	38.6	6.98	.94	51.93
8	272	.543	233.	.0586	25.2	6.58	.46	67.15
9	251	.481	207.	.0535	23.0	5.90	.92	81.20
10	335	.475	204.	.0449	19.3	5.59	.59	99.94

(continued)

TABLE 3-3. (CONTINUED)

NO PROBABILITY

NO CELL DIMENSIONS

CELL NUMBER	CENTER LB/10**6 BTU	CENTER NG/J	LOWER BOUNDARY LB/10**6 BTU	LOWER BOUNDARY NG/J	UPPER BOUNDARY LB/10**6 BTU	UPPER BOUNDARY NG/J
1	.187	80.	.155	67.	.219	94.
2	.251	108.	.219	94.	.283	122.
3	.315	135.	.283	122.	.347	149.
4	.379	163.	.347	149.	.411	177.
5	.443	190.	.411	177.	.475	204.
6	.507	218.	.475	204.	.539	232.
7	.571	245.	.539	232.	.603	259.
8	.635	273.	.603	259.	.667	287.
9	.699	300.	.667	287.	.731	314.
10	.763	328.	.731	314.	.795	342.

NO PROBABILITY RESULTS

CELL NUMBER	NUMBER OF ENTRIES	CUM. PROB. PERCENT LESS THAN
1	2	.11
2	0	.11
3	11	.73
4	272	15.95
5	558	47.17
6	486	74.37
7	332	92.95
8	91	98.04
9	26	99.50
10	8	99.94

(continued)

TABLE 3-3. (CONTINUED)

```
                 **NOX COMPLIANCE WITH RESPECT TO 1971 NSPS**
  FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
    FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)
  FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)
              THIS BOILER WAS OPERATED WITH SUBBITUMINOUS COAL
   THE NOX MEASURED DURING THE PERFORMANCE TEST WAS   .503  LB/10**6 BTU (216. NG/J)
AN ANALYSIS OF 3-HOUR NO  ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
         INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON    17  OCCASIONS
AN ANALYSIS OF 3-HOUR NO  BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
         INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     6  OCCASIONS
```

(continued)

TABLE 3-3.   (CONTINUED)

```
                 **NOX COMPLIANCE WITH RESPECT TO 1978 NSPS**

                   1978 NSPS NOX EMISSION LIMITATIONS
            SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
              BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
   LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
              OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)


    ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED     0  EXCEEDANCES

                         30-DAY ROLLING AVERAGES
          EMISSION LIMITATION  .50 LB/10**6 BTU  215. NG/J

               SEQUENTIAL            30-DAY AVERAGE NO
                AVERAGE            LB/10**6 BTU  NG/J
               ----------          ------------  ----
                    1                  .482       207.
                    2                  .485       208.
                    3                  .488       210.
                    4                  .487       209.
                    5                  .491       211.
                    6                  .492       211.
                    7                  .492       211.
                    8                  .493       212.
                    9                  .493       212.
                   10                  .492       211.
                   11                  .493       212.
                   12                  .494       212.
                   13                  .490       210.
                   14                  .489       210.
                   15                  .491       211.
                   16                  .492       211.
                   17                  .490       211.
                   18                  .489       210.
                   19                  .489       210.
                   20                  .489       210.
                   21                  .488       210.
                   22                  .487       209.
                   23                  .489       210.
                   24                  .492       211.
                   25                  .495       213.
                   26                  .496       213.
                   27                  .495       213.
                   28                  .495       213.
                   29                  .493       212.
                   30                  .490       210.
                   31                  .490       211.
                   32                  .489       210.
                   33                  .490       210.
                   34                  .489       210.
                   35                  .488       209.
                   36                  .490       211.
                   37                  .495       212.
                   38                  .498       214.
                   39                  .496       213.
                   40                  .495       213.
                   41                  .496       213.
                   42                  .497       214.
                   43                  .496       213.
                   44                  .492       211.
                   45                  .489       210.
                   46                  .488       210.
                   47                  .487       209.
                   48                  .490       210.
                   49                  .495       212.
```

TABLE 3-4. REVISED COMPUTER ANALYSIS - MUSKOGEE UNIT 5

```
                         **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
---------------------------------------------------------------------------------------------
DATA SUBMITTED BY OKLAHOMA GAS AND ELECTRIC

MUSKOGEE STATION UNIT 5  SUBBITUMINOUS COAL  MON. REL. ACC. = 18.2 PC
-----------------------------------------------------------------------------------------
DAY 1 IS OCTOBER 15, 1980     DAY 94 IS JANUARY 16, 1981
------------------------------------------------------------------------------------
550 MWE, COMBUSTION ENGINEERING BOILER WITH OVERFIRE AIR

COAL PROPERTIES IDENTICAL TO UNIT 4
--------------------------------------------------------------------------------
BOILER OFF-LINE FROM DEC. 13, 1980 TO DEC. 24, 1980 INCLUSIVE
```

(continued)

TABLE 3-4. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
2	.278	120.	.0807	34.7	5.6	2.78	385.	118.2
7	.506	218.	.0437	18.8	9.0	.81	269.	66.8
9	.484	208.	.0680	29.2	9.3	.99	249.	78.5
10	.501	215.	.0438	18.8	8.3	1.36	325.	107.8
13	.391	168.	.0616	26.5	6.4	1.38	426.	84.3
23	.356	153.	.0851	36.5	7.5	1.84	311.	104.2
28	.386	166.	.1384	59.5	6.4	2.63	381.	155.4
30	.337	145.	.1172	50.4	6.0	2.27	392.	127.7
37	.404	173.	.0250	10.7	6.3	.41	439.	21.2
39	.411	177.	.0225	9.7	6.5	.64	426.	52.5
40	.433	186.	.1302	55.9	7.5	1.91	347.	123.5
41	.394	169.	.0611	26.3	6.8	1.64	401.	111.2
43	.378	162.	.0733	31.5	6.7	1.51	422.	80.8
44	.352	151.	.0215	9.2	6.1	.11	452.	3.0
45	.384	165.	.0445	19.1	7.3	1.10	369.	73.1
56	.380	163.	.0268	11.5	6.3	.27	440.	17.9
57	.415	178.	.0411	17.6	6.3	.22	443.	13.5
72	.284	122.	.0620	26.6	10.2	1.09	138.	7.5
73	.272	117.	.0423	18.2	10.0	.00	135.	1.6
88	.605	260.	.1098	47.2	7.3	1.00	365.	50.9
89	.627	270.	.1185	50.9	8.5	.88	301.	45.5

(continued)

TABLE 3-4. (CONTINUED)

NO AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	125.	104.	146.
2	167.	146.	188.
3	209.	188.	231.
4	252.	231.	273.
5	294.	273.	315.
6	336.	315.	357.
7	378.	357.	399.
8	420.	399.	442.
9	463.	442.	484.
10	505.	484.	526.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD PROB. PERCENT
1	42	.278	119.	.0532	22.9	10.12	.79	9.19
2	54	.522	224.	.0671	28.8	9.96	.20	21.01
3	12	.516	222.	.1156	49.6	9.64	.59	23.63
4	13	.583	250.	.1326	57.0	9.22	.51	26.48
5	19	.573	246.	.1766	75.9	8.62	.84	30.63
6	50	.440	189.	.0901	38.7	7.84	.63	41.58
7	17	.454	195.	.0962	41.3	6.91	.76	45.30
8	59	.407	175.	.0908	39.0	6.54	.72	58.21
9	163	.367	157.	.0470	20.2	5.94	.54	93.87
10	27	.258	111.	.0359	15.4	4.01	.67	99.78

(continued)

TABLE 3-4. (CONTINUED)

NO PROBABILITY

NO CELL DIMENSIONS

CELL NUMBER	CENTER LB/10**6 BTU	CENTER NG/J	LOWER BOUNDARY LB/10**6 BTU	LOWER BOUNDARY NG/J	UPPER BOUNDARY LB/10**6 BTU	UPPER BOUNDARY NG/J
1	.198	85.	.165	71.	.231	99.
2	.264	113.	.231	99.	.297	128.
3	.330	142.	.297	128.	.363	156.
4	.396	170.	.363	156.	.429	184.
5	.462	198.	.429	184.	.495	213.
6	.528	227.	.495	213.	.561	241.
7	.594	255.	.561	241.	.627	269.
8	.660	284.	.627	269.	.693	298.
9	.726	312.	.693	298.	.759	326.
10	.792	340.	.759	326.	.825	354.

NO PROBABILITY RESULTS

CELL NUMBER	NUMBER OF ENTRIES	CUM. PROB. PERCENT LESS THAN
1	14	3.06
2	63	16.85
3	105	39.82
4	113	64.55
5	64	78.56
6	53	90.15
7	26	95.84
8	10	98.03
9	3	98.69
10	5	99.78

(continued)

TABLE 3-4. (CONTINUED)

```
**NOX COMPLIANCE WITH RESPECT TO 1971 NSPS**
FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)
FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)
THIS BOILER WAS OPERATED WITH SUBBITUMINOUS COAL
THE NOX MEASURED DURING THE PERFORMANCE TEST WAS   .624  LB/10**6 BTU (268. NG/J)
AN ANALYSIS OF 3-HOUR NO  ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     5  OCCASIONS
AN ANALYSIS OF 3-HOUR NO  BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     2  OCCASIONS
INSUFFICIENT DATA TO CALCULATE 30-DAY ROLLING AVERAGES
```

Units 4 and 5 are fueled with the same coal and the utility supplied 48 proximate analyses of heating value, sulfur, ash and moisture. These analyses were divided into three monthly sets and Table 3-5 presents the means and standard deviations of each parameter. The heating value, on a dry, ash-free basis, varied by only 0.47 percent within this time period supporting the conclusion of coal property constancy.

The Lear Siegler continuous emission monitors (CEMs) were certified on April 15, 1978 for Unit 4 and November 12, 1979 for Unit 5. The Unit 5 CEM was tested during December 1980 as part of a system audit and the NO analyzer relative accuracy was found to be 7.3 percent as compared to 18.3 percent during the original certification. Tables 3-6 and 3-7 tabulate the results of each performance specification test.

At this time there is no explanation for the NO emission characteristics with load for Unit 5. As discussed in the site visit (Section 3.2) the coating of the waterwalls and operation of the overfire air system for Unit 5 should have resulted in higher NO emissions than measured on Unit 4. This matter was not resolved within the scope of the present study.

The input data for both the initial and revised computer analyses are contained in Appendices B through E in Volume II.

3.2 SITE VISIT

On July 21, 1981, a meeting was held with Mr. Larry Hatley, Senior Results Engineer, to discuss monitor and boiler operation.

3.2.1 Boiler Design

- Boiler manufacturer is Combustion Engineering (CE).
- Burner design is tilting tangential with overfire air (OFA) above top row of burners.
- Six levels of burners.
- Coal-fired is Wyoming subbituminous.
- Furnace heat release rate is 11,880 Btu/hr-ft^3.

(text continued on page 3-41)

TABLE 3-5. COAL PROPERTIES--OKLAHOMA GAS & ELECTRIC, MUSKOGEE STATION, UNITS 4 & 5

	Time Period			
Parameter	**10-15-80/11-14-80**	**11-15-80/12-14-80**	**12-15-80/1-16-81**	**10-15-80/1-16-81**
Sample Size	15	16	17	48
Mean Heating Value Btu/lb (kJ/kg)	8790 (20,450)	8830 (20,540)	8850 (20,590)	8820 (20,520)
Heating Value Stand. Dev. Btu/lb (kJ/kg)	41 (95)	39 (91)	47 (110)	51 (120)
Mean Sulfur Content, %	0.34	0.36	0.35	0.35
Sulfur Stand. Dev., %	0.032	0.041	0.042	0.039
Mean Ash Content, %	4.92	4.67	4.73	4.77
Ash Stand. Dev., %	0.43	0.17	0.22	0.30
Mean Moisture Content, %	27.8	27.6	27.7	27.6
Moisture Stand. Dev., %	0.39	0.20	0.23	0.29

TABLE 3-6. NO ANALYZER CERTIFICATION RESULTS -- MUSKOGEE STATION UNITS 4 AND 5

Parameter	EPA Specification	Unit 4	Unit 5
Relative Accuracy	≤20%	10.9%	18.2%*
Calibration Error	≤5%	2.3% (mid-range) 1.3% (high-range)	2.2% (mid-range) 0.6% (high-range)
Zero Drift (2-hr)	≤2% of span	0.1%	0.4%
Zero Drift (24-hr)	≤2% of span	0.2%	0.78%
Calibration Drift (2-hr)	≤2% of span	0.3%	0.54%
Calibration Drift (24-hr)	≤2.5% of span	0.3%	0.74%
Response Time	15 min. maximum	2.0 minute	1 minute
Operational Period	168 hour minimum	168	168

*Retest during December 1980: relative accuracy = 7.3%.

TABLE 3-7. O_2 ANALYZER CERTIFICATION RESULTS -- MUSKOGEE STATION UNITS 4 AND 5

Parameter	EPA Specification	Unit 4	Unit 5
Zero Drift (2-hour)	$\leq 0.4\%\ O_2$	$0.1\%\ O_2$	$0.1\%\ O_2$
Zero Drift (24-hour)	$\leq 0.5\%\ O_2$	$0.2\%\ O_2$	$0.1\%\ O_2$
Calibration Drift (2-hr)	$\leq 0.4\%\ O_2$	$0.1\%\ O_2$	$0.1\%\ O_2$
Calibration Drift (24-hr)	$\leq 0.5\%\ O_2$	$0.3\%\ O_2$	$0.1\%\ O_2$
Response Time	10 min maximum	0.1 minute	0.1 minute
Operational Period	168 hour minimum	168	168

- Generator output of 550 MWe gross.

- OFA direction angle was set by CE at 30° up (from horizontal) for both units 4 and 5. (As the burners are tilted for superheat temperature control, the relative angle between the burners and OFA changes. This angle affects the NO_x.) The burner/OFA angular relationships at high-load are shown in Figure 3-11.

3.2.2 Operational Items

- O_2 Operation: Both units operate with O_2 curves designed into the combustion control system and operate with 10 percent O_2 at 30 percent load down to 3.5 percent O_2 at 100 percent load. Subsequent to the site visit and data analysis the plant personnel lowered the O_2 curve for Unit 5 in order to control NO at low loads, and carry more load without exceeding the precipitator draft limit.

- Heat Rate: Unit 5 averages ~10,400 Btu/kWh and Unit 4 averages ~11,000 Btu/kWh (due to steam temperature degradation).

- Steam Temperatures: Designed steam temperatures are 1000°F/1000°F superheat/reheat, however, both units experienced significant steam temperature deficiencies; on the order of 940 - 960°F. In February 1980, CE completed modifications on Unit 5 in an effort to correct this deficiency. The modifications included removal of reheat surface area and coating the waterwalls to reduce the heat transfer in the furnace. Subsequent to these modifications, Unit 5 has been operating at design steam temperatures. One would think that coating the waterwalls would, in effect, increase the NO_x emissions. The CEMS data, however, do not indicate this. Plans call for Unit 4 to undergo these same modifications during the fall of 1981.

- OFA Operation: Both units' OFA operation are automatically controlled. The OFA dampers begin opening at 60 percent load and continue to 100 percent open at 90 percent load. At present, Unit 5 is operating with the OFA dampers 100 percent open all of the time in order to control NO at low loads.

- Slagging/Fouling Characteristics: Neither unit has experienced slagging problems, however, both units have similar problems with convective pass fouling and pluggage. Both units experience packing in the super-heat finishing section near the economizer. After a period of time, chunks drop off and begin to plug the economizer. CE and the utility have not been able to determine, or correct, the cause of this problem.

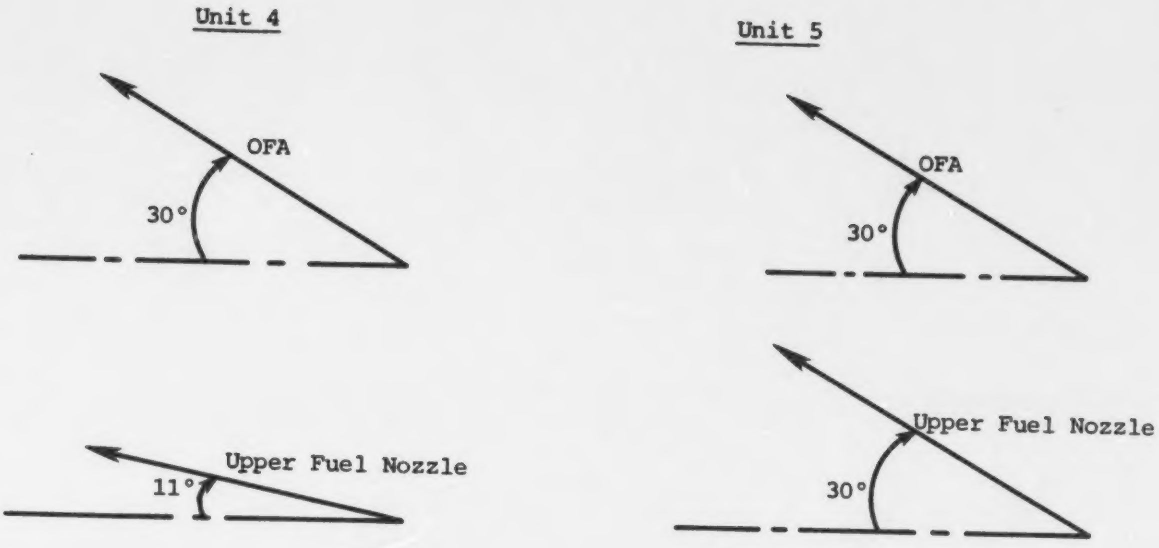


Figure 3-11. Muskogee Units 4 and 5 -
OFA and Fuel Nozzle Relationships at High-Load

- Unit Availability: Both units have experienced load limitations periodically due to the above-mentioned pluggage problem. The utility has observed that the pluggage begins and then stabilizes to a fairly constant level. The load capability drops from 530 MWe down to ~450 MWe over a period of about 8 months. The utility schedules the removal of these deposits with regularly scheduled maintenance outages. Usually two weeks are required to remove these deposits.

- Ash Carbon Characteristics: Typically there is virtually no carbon in the ash, but they have had occasional excursions up to ~5 percent carbon.

- Tube Wastage: The only wastage problem experienced by these units has been tube erosion due to high velocity gradients resulting from the pluggage problem.

- NO Emissions Excursions: The only NO excursion problems occur at low load (150 MWe) conditions (due to high O_2 levels). The high O_2 levels are recommended by CE for maintaining flame stability and steam temperatures. This point illustrates the fact that it is not uncommon for boilers to produce higher NO concentrations at intermediate load levels than at full load conditions. Compliance test NO_x emissions levels (conducted at full load conditions), therefore, are not necessarily indicative of a boiler's maximum NO_x concentration.

3.2.3 Continuous Emissions Monitoring System

- Make and Model: The CEMS for both units are Lear Siegler SM810s. The CEMS were originally SM800s, however, LS performed a series of modifications to convert them to SM810s. The primary reason for the conversion was to improve the reliability of the instruments. These in situ monitors are measuring NO only and not NO_x.

- Monitor Certification Dates:
  #4 Unit CEM: 4-15-78
  #5 Unit CEM: 11-12-79; retest during December 1980

- CEM Location: The location of CEMS for both units is in the stack (downstream of the air heaters) at the 270-ft. elevation.

- Oxygen analyzers; CEM/Boiler: Boiler oxygen levels are measured in the ducts before the air heaters and in the stack at the CEM location. The differences in operating excess oxygen levels between units 4 and 5 could not be explained by the plant personnel.

- CEM Data Reduction: The CEMS are certified to strip charts only, with report data obtained manually from same. The EPA "F" factor is used to calculate NO_x emissions. The emissions reduced via computer are for informational purposes only, i.e., not officially certified.

- Monitor Certification:

  (1) The original certification data for Units 4 and 5 showed that the NO relative accuracy was 10.9 percent and 18.2 percent, respectively.

  (2) The Unit 4 CEM has not been tested since the original date. The Unit 5 CEM was tested on one occasion since the original date. The test was conducted by Entropy Environmentalists, Inc. in December 1980 and the results showed the CEM was operating within EPA specifications. This test showed the CEM NO relative accuracy was 7.3 percent. This test was part of a performance/system audit of the CEM conducted under the auspices of the EPA. Entropy conducted the performance portion and Engineering-Science conducted the CEM System Audit portion.

  (3) Relative accuracy tests are not regularly scheduled.

- Calibration Procedure:

  (1) Description - The CEMS use a glass cell, filled with the appropriate calibration reference gases, inserted into the light path.

  (2) Operation - The CEMS go through an automatic calibration check every two hours, however, adjustments are performed manually once a day (8:00 a.m.). The calibration checks are recorded on the strip charts. The calibration checks are also programmed into the computer and if the calibration is out of spec (a deviation of 5 ppm for zero, and 59 ppm for span) a flag ($ or $$) is printed beside the out-of-spec parameter. When these flags are encountered one only knows the value is out of spec, but not to what degree. The corresponding strip charts would have to be reviewed to determine this. Review of the data supplied by OG&E shows that the Unit 5 CEM experiences substantially more calibration excursions than Unit 4. The plant has observed that as the CEM heats up during the day, the NO ppm drifts downward.

- Quality Assurance Procedures:

  Quality assurance forms are filled out daily by a technician permanently assigned to maintain the CEMS. This person also performs an inspection of the stack portion of the CEM once a week. This person is also responsible for CEM repairs when malfunctions occur.

- CEM Operation and Availability History:

  Both CEMS had experienced considerable problems prior to the modifications to convert to SM810s, but, since the modifications, the CEMS have operated relatively trouble-free.

3.2.4 Evaluation of NO Deviation Between Units 4 and 5

Figure 3-7 shows the NO_x emissions profiles for both units and that the NO emissions begin to deviate at about 300 MWe. Various areas were investigated to explain the deviation; the physical boiler/burner configuration, boiler operation, fuel supply, and CEM operation. The physical boiler/burner configuration was originally identical, but Unit 5 underwent the modifications discussed in Section 3.2.2. One would predict that the results of the modifications would be to increase the NO emissions, but this is not observed in the data. The position and operation of the OFA system is different as shown in Figure 3-11. This difference should have increased the NO emissions from Unit 5 relative to Unit 4 (Reference 2).

The only differences observed relative to boiler operation involve the oxygen levels shown in Figure 3-8. The oxygen operation for both units is very similar up to a load of 450 MWe. The oxygen deviation noted at 500 MWe would explain a portion of the corresponding NO emissions deviation at 500 MWe, but the NO deviations at the lower loads are not related to the oxygen operation.

Both units fire the same coal and, thus, the NO deviations cannot be due to fuel supply deviations.

Based on the CEM calibration procedure previously discussed the CEM NO data for Unit 5 appears to be questionable. This is very possibly the source of the NO deviations. The strip charts would have to be examined before one could quantify the magnitude of the calibration deviations and, hence, the magnitude of the NO deviations. Any further effort to resolve the NO deviations should be directed first to resolving the CEM calibration deviations.

3.2.5 Coal

The coal supply for both units is from two sources: Black Thunder (ARCO); and Belle Ayr (AMEX) with the former supplying 80 percent of the total. The coal is not subject to any cleaning procedures.

3.2.6 Flue Gas Desulfurization

Neither unit is equipped with a flue gas desulfurization system.

SECTION 4.0

OMAHA PUBLIC POWER DISTRICT - NEBRASKA CITY STATION, UNIT 1

4.1 EMISSIONS ANALYSIS

Information obtained on this unit is included for completeness only. Approximately fifteen calendar-months were required to provide 31 days of monitoring data. NO monitoring was discontinued with the approval of the Nebraska Department of Environmental Control following performance tests which showed that the station NO emissions were less than 70 percent of the applicable standard. Tables 4-1 and 4-2 present boiler design features and typical coal properties obtained during a previous utility visit.

Table 4-3 is the computer analysis summary from which the boiler characteristics were developed. Figure 4-1 displays these characteristics. The data used in computing these characteristics includes 21 days of data when the monitoring equipment indicated abnormal zero and/or span values. With the data used, it is noted that the monitored NO at high-load exceeds the performance test value by about 19 percent. The NO distribution, as represented in log-normal probability coordinates (Figure 4-2) results in a geometric mean of 215 ng/J and a geometric dispersion of 1.25. The load probability, Figure 4-3, indicates a median of 380 MWe (66.1 percent of rating).

The analysis in terms of the 1978 NSPS is inconclusive as only two 30-day rolling averages could be calculated from the inaccurate data. Both of these averages would have resulted in periods of excess emissions.

The in-situ Lear Siegler SM810 NO analyzer original CEM certification test and performance evaluation was completed on March 17, 1980. The results of this evaluation are shown in Table 4-4.

The hourly-averaged input data are contained in Appendix F.

TABLE 4-1. NEBRASKA CITY STATION, UNIT 1 - BOILER DESIGN FEATURES

Boiler Manufacturer	Foster Wheeler
Rating-MW (gross)	575
Firing Mode	Opposed Face
Number of Burners	28
Number of Burner Levels	4 rows of 4 burners each-front face 3 rows of 4 burners each-rear face
Burner Type	Intervane (Forney)
Other NO_x Controls	Interstage Air between 3rd & 4th levels-front face between 2nd & 3rd levels-rear face
Coal Type	Subbituminous
Performance NO_x-lb/10^6Btu	0.479
-ng/J	206
Particulate Control	Hot-side ESP
Sulfur Dioxide Control	None (low-sulfur coal)

TABLE 4-2. NEBRASKA CITY STATION, UNIT 1 - TYPICAL COAL PROPERTIES

As Received Coal Analysis - % By Weight	
Carbon	46.64
Hydrogen	3.31
Nitrogen	0.70
Oxygen	11.86
Sulfur	0.57
Chlorine	0.01
Ash	6.55
Moisture	30.36

Higher Heating Value	
Btu/lb	8,127
kJ/kg	18,903

SiO_2	33.09	Na_2O	0.12
Al_2O_3	16.64	SO_3	11.50
TiO_2	0.97	P_2O_5	2.23
Fe_2O_3	5.61	SrO	0.51
CaO	21.78	BaO	0.63
MgO	4.21	Mn_3O_4	0.02
K_2O	0.35		

TABLE 4-3. COMPUTER ANALYSIS SUMMARY - NEBRASKA CITY UNIT 1

```
                            **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
OMAHA PUBLIC POWER DISTRICT NEBRASKA CITY STATION UNIT 1
575 MWE, FOSTER WHEELER BOILER OPPOSED FACE FIRED WITH INTERSTAGE AIR
NO  MONITOR RELATIVE ACCURACY = 18.2 PC  SUBBITUMINOUS (C) COAL
DUE TO MONITOR INOPERATIVENESS OR INACCURACY ONLY 31 DAYS OF DATA HAVE
BEEN OBTAINED
DAY 1 = 8-25-79, DAY 15 = 3-12-80, DAY 22 = 5-15-80, DAY 31 = 5-24-80
```

(continued)

TABLE 4-3. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
1	.607	261.	.0337	14.5	7.3	.16	300.	39.4
2	.618	266.	.0516	22.1	8.2	.81	254.	39.7
3	.624	268.	.0863	37.1	7.6	.77	360.	114.4
4	.523	225.	.0693	29.8	7.7	.82	311.	91.2
5	.623	268.	.0745	32.0	7.1	.61	389.	115.0
6	.652	280.	.0620	26.6	6.2	.24	485.	65.8
7	.530	228.	.0735	31.6	6.2	.13	461.	66.9
8	.485	209.	.1653	71.0	6.9	.43	342.	103.6
9	.483	207.	.0934	40.1	6.9	.38	311.	84.6
10	.499	214.	.1539	66.1	7.1	.31	315.	105.5
11	.495	213.	.0849	36.5	7.2	.36	338.	99.7
12	.477	205.	.0426	18.3	7.1	.17	402.	79.6
13	.492	211.	.1096	47.1	7.1	.32	365.	81.6
14	.407	175.	.0584	25.1	7.6	.97	279.	68.2
15	.422	181.	.1059	45.5	7.8	.93	339.	125.5
16	.581	250.	.0359	15.4	6.8	.50	480.	108.2
17	.553	238.	.0723	31.0	6.8	.06	464.	69.8
18	.547	235.	.0616	26.5	6.9	.18	428.	62.7
19	.532	229.	.0626	26.9	6.9	.20	445.	78.8
20	.539	232.	.0510	21.9	6.4	.52	496.	74.8
21	.438	188.	.0720	30.9	6.1	.29	464.	60.5
22	.451	194.	.0843	36.2	7.4	1.17	301.	114.5
23	.446	191.	.0388	16.7	6.8	1.51	408.	141.3
24	.388	167.	.0693	29.8	6.6	1.11	385.	114.4
25	.395	170.	.0633	27.2	8.3	.69	244.	14.5
26	.628	270.	.0754	32.4	7.2	1.03	376.	98.3
27	.682	293.	.0943	40.5	7.0	1.15	414.	112.0
28	.617	265.	.0739	31.7	6.6	-1.03	444.	132.7
29	.556	239.	.0916	39.3	6.8	1.09	401.	107.7
30	.601	258.	.0844	36.2	7.2	1.14	388.	133.1
31	.520	223.	.0476	20.5	7.9	.52	277.	35.9

(continued)

TABLE 4-3. (CONTINUED)

NO AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	36.	5.	68.
2	99.	68.	131.
3	162.	131.	194.
4	225.	194.	257.
5	288.	257.	320.
6	351.	320.	383.
7	414.	383.	446.
8	477.	446.	509.
9	540.	509.	572.
10	603.	572.	635.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD PROB. PERCENT
1	2	.175	75.	.1344	57.7	9.90	.14	.27
2	3	.333	143.	.0757	32.5	9.93	.06	.68
3	9	.409	176.	.0533	22.9	9.27	.36	1.90
4	141	.502	215.	.1444	62.0	8.23	.64	21.06
5	115	.495	213.	.0917	39.4	7.39	.44	36.68
6	108	.498	214.	.0919	39.5	7.04	.34	51.36
7	108	.542	233.	.1008	43.1	6.72	.39	66.03
8	134	.582	250.	.0890	38.2	6.60	.45	84.24
9	90	.583	250.	.0776	33.4	6.17	.44	96.47
10	25	.567	243.	.0855	36.7	5.72	.38	99.86

(continued)

TABLE 4-3. (CONTINUED)

NO PROBABILITY

NO CELL DIMENSIONS

CELL NUMBER	CENTER LB/10**6 BTU	NG/J	LOWER BOUNDARY LB/10**6 BTU	NG/J	UPPER BOUNDARY LB/10**6 BTU	NG/J
1	.116	50.	.075	32.	.156	67.
2	.196	84.	.156	67.	.237	102.
3	.277	119.	.237	102.	.318	137.
4	.359	154.	.318	137.	.399	171.
5	.440	189.	.399	171.	.480	206.
6	.520	224.	.480	206.	.561	241.
7	.601	258.	.561	241.	.642	276.
8	.682	293.	.642	276.	.723	311.
9	.763	328.	.723	311.	.804	345.
10	.844	363.	.804	345.	.885	380.

NO PROBABILITY RESULTS

CELL NUMBER	NUMBER OF ENTRIES	CUM. PROB. PERCENT LESS THAN
1	1	.14
2	0	.14
3	23	3.26
4	74	13.32
5	138	32.07
6	178	56.25
7	212	85.05
8	96	98.10
9	9	99.32
10	4	99.86

(continued)

TABLE 4-3. (CONTINUED)

```
                    **NOX COMPLIANCE WITH RESPECT TO 1971 NSPS**
         FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
           FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)
         FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)
                      THIS BOILER WAS OPERATED WITH SUBBITUMINOUS COAL
          THE NOX MEASURED DURING THE PERFORMANCE TEST WAS   .479  LB/10**6 BTU (206. NG/J)
AN ANALYSIS OF 3-HOUR NO  ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
              INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON    30  OCCASIONS
AN ANALYSIS OF 3-HOUR NO  BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
              INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON    12  OCCASIONS
```

(continued)

TABLE 4-3. (CONTINUED)

```
                **NOX COMPLIANCE WITH RESPECT TO 1978 NSPS**

                     1978 NSPS NOX EMISSION LIMITATIONS
              SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
                BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
   LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
                OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)


 ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED     2  EXCEEDANCES

                       30-DAY ROLLING AVERAGES
             EMISSION LIMITATION  .50 LB/10**6 BTU  215. NG/J

              SEQUENTIAL               30-DAY AVERAGE NG
               AVERAGE                LB/10**6 BTU  NG/J
              ----------              ------------  ----
                  1                       .530      228.
                  2                       .527      226.
```

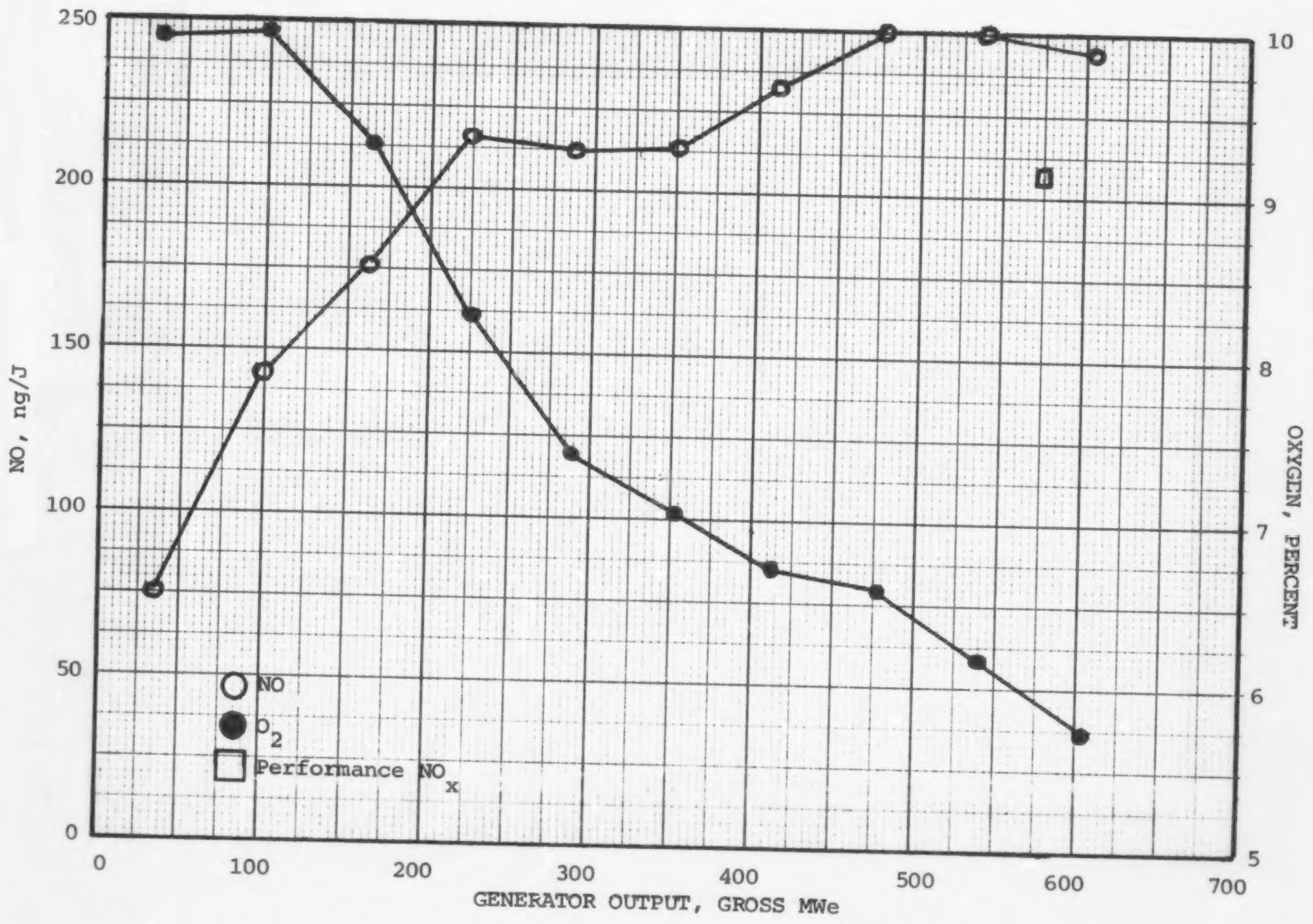
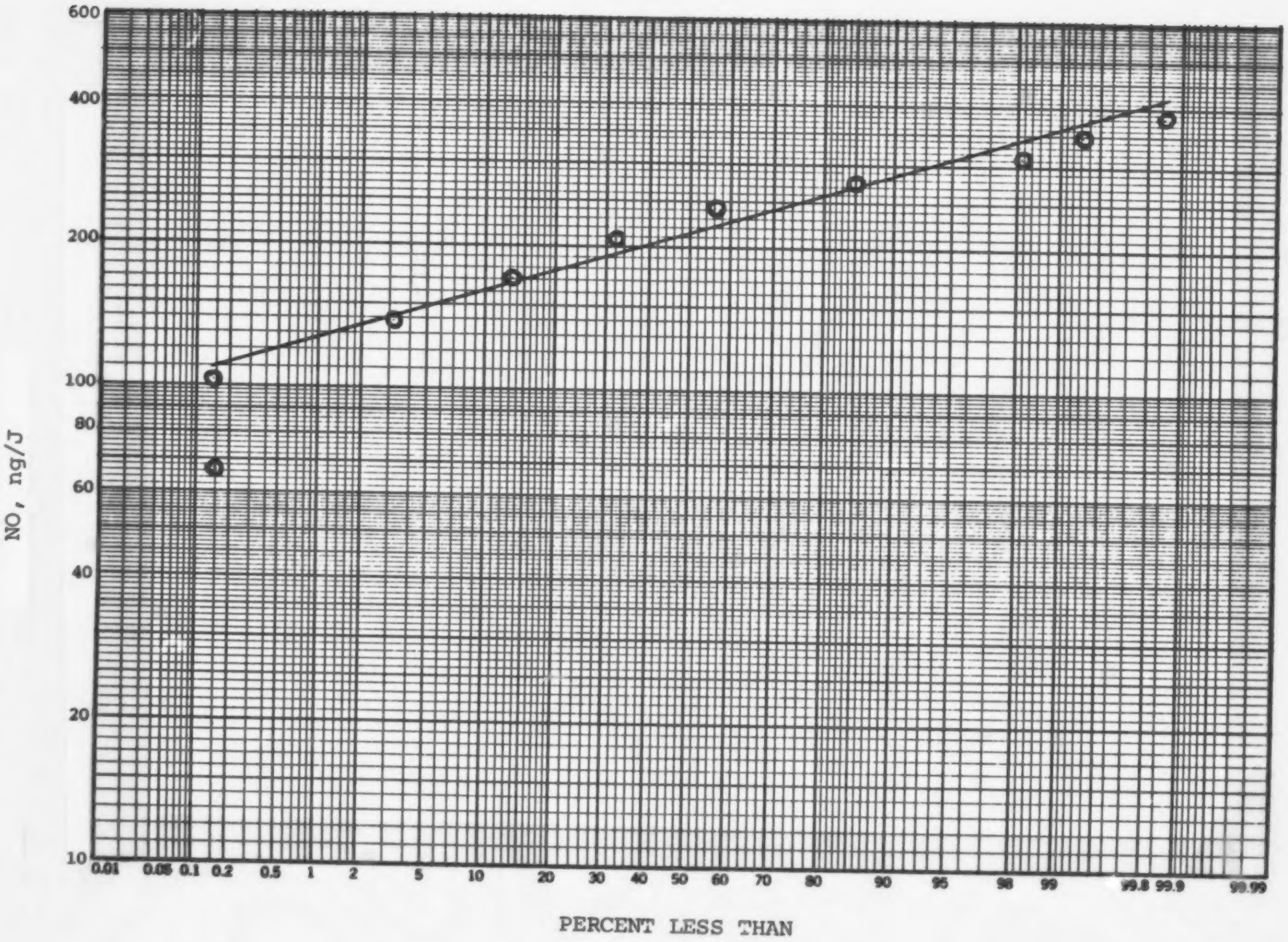


Figure 4-1. Nebraska City Unit 1 - Boiler Characteristics



4-3

Figure 4-2. Nebraska City Unit 1 - NO Probability

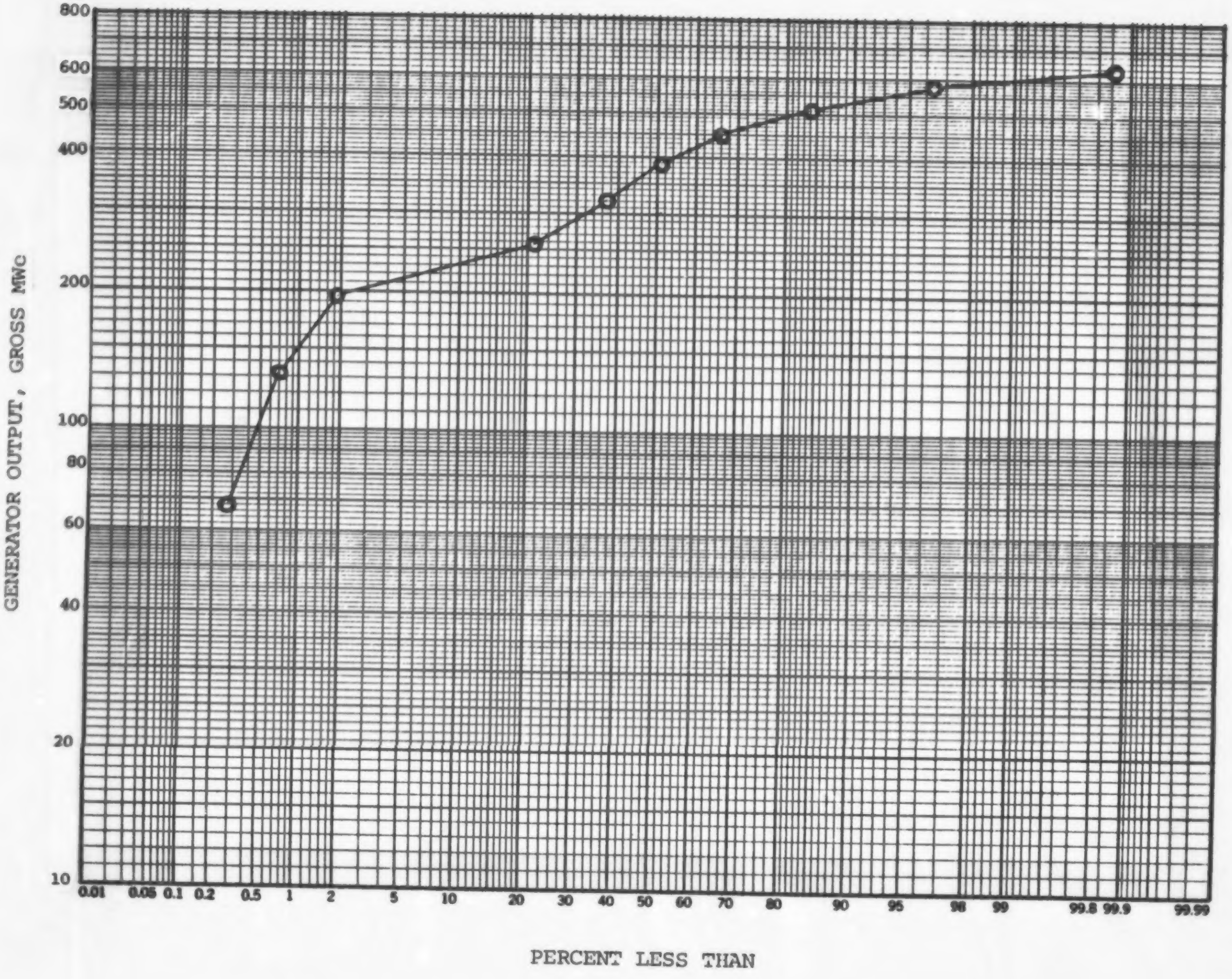


Figure 4-3. Nebraska City Unit 1 - Load Probability

TABLE 4-4. NO ANALYZER PERFORMANCE TEST RESULTS--NEBRASKA CITY STATION UNIT 1

Parameter	EPA Specification	Test Result
Relative Accuracy	$\leq$20%	18.2%
Calibration Error	$\leq$5%	0% (mid-range) 0% (high-range)
Zero Drift (2-hour)	$\leq$2% of span	0%
Zero Drift (24-hour)	$\leq$2% of span	0%
Calibration Drift (2-hour)	$\leq$2% of span	0%
Calibration Drift (24-hour)	$\leq$2.5% of span	0.49%
Response Time	15 minute maximum	2.0 min.
Operational Period	168 hour minimum	168 hr.

SECTION 5.0

IOWA POWER AND LIGHT - COUNCIL BLUFFS STATION UNIT 3

5.1 EMISSIONS ANALYSIS

Emission data supplied for this unit covered the period of January - May 1981. However, the first 44 days were invalid since the CO_2 monitor was out of service. (The continuous emission monitor uses CO_2 as a dilution correction for NO).

The initial computer analysis included 2,283 hours of valid NO, CO_2 and load which was obtained over 108 calendar days. Excluding those days when the boiler was off-line or no data was supplied results in a monitor reliabilty (monitor/boiler operating hours) of 95.1 percent.

At high load unit operation is somewhat constrained because of an induced draft fan limitation. In addition, operation at all loads is performed at minimum air conditions for fuel efficiency considerations. To achieve these goals the boiler operators have displays of CO and O_2, and the boiler is equipped with an O_2 trim control using probes permanently installed in the economizer.

The initial computer analysis (Table 5-1) indicates the low NO measured on a daily and 30-day rolling average basis. The unit, had it been subject to the 1978 NSPS would have met the performance test and would not have experienced any periods of excess NO emissions. The 1971 NSPS performance test result (0.34 lb $NO_x/10^6$ Btu - 146 ng/J) is less than 70 percent of the 1971 standard and the utility does not have to file any excess NO reports and, according to the EPA NSPS, does not have to monitor NO.

The boiler NO and CO_2 versus load characteristic is shown in Figure 5-1. The load probability distribution (Figure 5-2) is of interest since it indicates a bimodal operation in log-normal coordinates, with an overall median load of 640 gross MWe (88.9 percent of rating). The NO probability is representable in terms of a normal distribution (Figure 5-3) with a mean and standard deviation of 134 ng/J and 21 ng/J, respectively.

(text continued on page 5-12)

TABLE 5-1. INITIAL COMPUTER SUMMARY - COUNCIL BLUFFS UNIT 3

```
                              **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
IOWA POWER AND LIGHT = COUNCIL BLUFFS UNIT 3

***NOTE = CO2 USED FOR DILUTION CORRECTION, NOT O2***

BABCOCK AND WILCOX BOILER WITH DUAL REGISTER BURNERS  720 GROSS MWE

WYOMING SUBBITUMINOUS COAL  NO  MON. REL. ACC. = 9.53PC

DAY 44 = 13 FEBRUARY 1981

PERFORMANCE NOX = 0.34 LB/10**6BTU  (146 NG/J)
```

(continued)

TABLE 5-1. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	CO2 MEAN PERCENT	CO2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
44	.386	166.	.0330	14.2	15.4	.27	667.	52.5
45	.349	150.	.0578	24.8	14.8	1.08	583.	76.6
46	.369	158.	.0420	18.1	12.6	.36	543.	100.9
47	.387	166.	.0591	25.4	12.5	.81	544.	122.7
48	.317	136.	.0597	25.7	15.2	1.18	570.	162.6
49	.307	132.	.0711	30.5	16.2	.46	602.	151.9
50	.304	130.	.0459	19.7	16.3	.30	597.	106.4
51	.311	134.	.0578	24.8	16.0	.33	599.	100.4
52	.281	121.	.0519	22.3	15.3	.42	520.	144.3
53	.284	122.	.0641	27.5	15.2	.26	530.	128.8
54	.346	149.	.0524	22.5	15.3	.16	636.	75.4
55	.352	151.	.0301	12.9	15.5	.31	636.	53.7
56	.388	166.	.0420	18.0	15.7	.17	628.	73.7
57	.344	148.	.0486	20.9	15.5	.10	620.	92.3
58	.336	144.	.0390	16.8	15.5	.15	626.	60.5
59	.320	138.	.0404	17.3	15.4	.11	618.	49.8
60	.307	132.	.0266	11.4	15.2	.11	575.	40.1
61	.332	143.	.0492	21.1	15.3	.12	622.	90.5
62	.332	142.	.0337	14.5	15.3	.17	631.	70.5
63	.308	133.	.0496	21.3	15.2	.24	603.	108.9
64	.309	133.	.0708	30.4	15.2	.28	601.	124.3
65	.324	139.	.0510	21.9	15.2	.30	620.	96.7
66	.325	139.	.0527	22.6	15.2	.25	597.	89.5
67	.327	141.	.0187	8.0	15.0	.20	576.	42.5
68	.352	151.	.0530	22.8	15.2	.21	616.	95.9
69	.320	137.	.0524	22.5	15.1	.51	599.	121.4
70	.318	137.	.0539	23.2	15.3	.27	604.	96.3
71	.312	134.	.0457	19.6	15.5	.37	602.	87.8
72	.310	133.	.0617	26.5	15.5	.23	587.	102.3
73	.317	136.	.0533	22.9	15.4	.32	582.	84.1
74	.269	115.	.0583	25.1	15.3	.33	528.	109.1
75	.355	152.	.0448	19.3	15.4	.14	623.	81.8
76	.340	146.	.0463	19.9	15.8	.32	637.	85.8
77	.351	151.	.0601	25.8	15.5	.18	635.	87.8
78	.350	151.	.0356	15.3	15.4	.25	640.	69.1
79	.311	134.	.0587	25.2	15.4	.13	611.	99.9
80	.321	138.	.0572	24.6	15.4	.21	625.	104.5
81	.300	129.	.0343	14.7	15.4	.21	583.	53.7
82	.351	151.	.0599	25.7	15.3	.17	600.	100.8
83	.322	139.	.0519	22.3	15.5	.31	583.	107.6
84	.327	141.	.0396	17.0	16.1	.22	610.	67.7
85	.321	138.	.0588	25.2	16.3	.30	602.	104.9
86	.314	135.	.0501	21.5	16.2	.25	601.	121.8
87	.286	123.	.0236	10.1	16.6	.30	592.	54.7
88	.306	132.	.0284	12.2	15.9	.19	547.	77.8
89	.310	133.	.0355	15.3	16.2	.26	619.	77.6
90	.290	125.	.0353	15.2	16.1	.16	590.	62.9
91	.293	126.	.0364	15.7	15.3	.91	582.	69.6
92	.298	128.	.0330	14.2	16.0	.01	597.	70.7
93	.280	120.	.0341	14.7	16.4	.40	599.	93.3
94	.280	120.	.0505	21.7	16.0	.15	600.	97.8
95	.302	130.	.0218	9.4	15.9	.12	617.	89.8

(continued)

TABLE 5-1. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO. MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	CO2 MEAN PERCENT	CO2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
96	.304	131.	.0257	11.1	16.1	.14	629.	51.3
97	.302	130.	.0332	14.3	16.4	.17	632.	60.6
98	.293	126.	.0226	9.7	16.1	.21	601.	75.3
99	.277	119.	.0392	16.8	16.1	.26	591.	89.7
100	.269	116.	.0399	17.1	16.0	.40	550.	136.3
105	.232	100.	.0305	13.1	16.2	.53	452.	111.0
106	.286	123.	.0399	17.1	16.9	.39	594.	81.3
108	.290	125.	.0466	20.0	17.1	.22	502.	81.3
110	.313	134.	.0092	3.9	17.0	.21	651.	31.6
111	.318	137.	.0109	4.7	16.9	.11	657.	22.4
112	.327	141.	.0130	5.6	16.9	.11	663.	20.1
113	.265	114.	.0450	19.3	16.8	.52	560.	122.1
114	.280	120.	.0333	14.3	17.6	.29	623.	76.3
115	.327	141.	.0349	15.0	16.3	1.02	655.	43.2
116	.332	143.	.0187	8.0	15.3	.19	620.	49.0
117	.309	133.	.0219	9.4	16.4	1.39	624.	51.7
118	.291	125.	.0307	13.3	17.3	.79	611.	55.0
119	.265	114.	.0591	25.4	17.5	.55	560.	123.4
120	.201	86.	.0254	10.9	16.8	.69	403.	96.9
121	.264	114.	.0449	19.3	17.8	.29	556.	91.6
122	.281	121.	.0365	15.7	17.6	.21	612.	80.0
123	.288	124.	.0270	11.6	17.5	.32	616.	77.2
124	.276	119.	.0455	19.6	17.4	.38	581.	109.6
126	.289	124.	.0189	8.1	17.5	.19	642.	44.5
127	.262	112.	.0347	14.9	17.3	.38	567.	100.2
128	.321	138.	.0493	21.2	16.8	1.14	610.	53.7
130	.310	133.	.0120	5.1	17.2	.26	655.	34.9
131	.295	127.	.0250	10.7	17.2	.18	628.	61.1
132	.305	131.	.0327	14.0	17.2	.14	635.	62.6
133	.265	114.	.0354	15.2	17.3	.95	583.	117.6
134	.280	120.	.0116	5.0	17.6	.17	632.	26.2
135	.291	125.	.0288	12.4	17.5	.19	635.	57.6
136	.320	137.	.0205	8.8	17.5	.14	669.	39.1
137	.318	137.	.0186	8.0	17.4	.17	644.	82.0
138	.297	127.	.0134	5.8	17.6	.24	648.	37.0
139	.282	121.	.0278	11.9	17.7	.14	634.	66.1
140	.258	111.	.0493	21.2	17.7	.34	607.	91.0
141	.272	117.	.0457	19.7	17.9	.34	588.	96.7
142	.350	150.	.0481	20.7	15.7	2.02	627.	80.9
143	.337	145.	.0446	19.1	13.0	.47	575.	107.1
148	.375	161.	.0245	10.5	14.1	.11	643.	34.6
149	.364	156.	.0316	13.6	14.5	.24	660.	43.3
150	.335	144.	.0505	21.7	14.0	.39	589.	100.6
151	.287	124.	.0521	22.4	14.1	.34	608.	61.5

(continued)

TABLE 5-1. (CONTINUED)

NO AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	147.	115.	179.
2	211.	179.	242.
3	274.	242.	306.
4	338.	306.	370.
5	402.	370.	433.
6	465.	433.	497.
7	529.	497.	561.
8	593.	561.	625.
9	656.	625.	688.
10	720.	688.	752.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO. MEAN LB/10**6 BTU	NO MEAN NG/J	NO. STD DEV LB/10**6 BTU	NO STD DEV NG/J	CO2 MEAN PERCENT	CO2 STD DEV PERCENT	LOAD PROB. PERCENT
1	1	.120	52.	.0000	.0	12.40	.00	.04
2	0	.000	0.	.0000	.0	.00	.00	.04
3	9	.197	84.	.0150	6.4	15.38	.34	.44
4	48	.200	86.	.0277	11.9	15.39	1.21	2.54
5	99	.229	98.	.0385	16.5	15.23	1.47	6.87
6	199	.245	105.	.0306	13.1	15.57	1.11	15.59
7	262	.273	117.	.0313	13.4	15.73	1.09	27.06
8	356	.300	129.	.0316	13.6	16.11	1.20	42.64
9	1094	.334	144.	.0357	15.3	16.20	1.16	90.54
10	215	.362	156.	.0271	11.6	15.95	.88	99.96

(continued)

TABLE 5-1. (CONTINUED)

```
                              **NO  PROBABILITY**

                               NO  CELL DIMENSIONS

                                                   LOWER                          UPPER
 CELL              CENTER                         BOUNDARY                       BOUNDARY
NUMBER       LB/10**6 BTU    NG/J         LB/10**6 BTU    NG/J          LB/10**6 BTU    NG/J
======       ============    ====         ============    ====          ============    ====
   1              .133        57.              .115        49.               .151        65.
   2              .169        73.              .151        65.               .187        80.
   3              .205        88.              .187        80.               .223        96.
   4              .241       104.              .223        96.               .259       111.
   5              .277       119.              .259       111.               .295       127.
   6              .313       134.              .295       127.               .331       142.
   7              .349       150.              .331       142.               .367       158.
   8              .385       165.              .367       158.               .403       173.
   9              .421       181.              .403       173.               .439       189.
  10              .457       196.              .439       189.               .475       204.

                           NO  PROBABILITY RESULTS

                                                     CUM. PROB.
                   CELL             NUMBER OF         PERCENT
                  NUMBER             ENTRIES         LESS THAN
                  ======            =========        ==========
                     1                   2                .09
                     2                  36               1.66
                     3                 116               6.74
                     4                 214              16.11
                     5                 437              35.25
                     6                 746              67.91
                     7                 400              85.42
                     8                 291              98.16
                     9                  29              99.43
                    10                  12              99.96
```

(continued)

TABLE 5-1. (CONTINUED)

```
                 . **NOX COMPLIANCE WITH RESPECT TO 1971 NSPS**
     FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
       FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)
     FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)
                THIS BOILER WAS OPERATED WITH SUBBITUMINOUS COAL
     THE NOX MEASURED DURING THE PERFORMANCE TEST WAS   .340  LB/10**6 BTU (146. NG/J)
AN ANALYSIS OF 3-HOUR NO  ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
       INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     0  OCCASIONS
AN ANALYSIS OF 3-HOUR NO  BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
       INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     0  OCCASIONS
```

(continued)

TABLE 5-1. (CONTINUED)

NOX COMPLIANCE WITH RESPECT TO 1979 NSPS

1979 NSPS NOX EMISSION LIMITATIONS
SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)

ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED 0 EXCEEDANCES

30-DAY ROLLING AVERAGES
EMISSION LIMITATION .50 LB/10**6 BTU 215. NG/J

SEQUENTIAL AVERAGE	30-DAY AVERAGE NO LB/10**6 BTU	NG/J
1	.328	141.
2	.324	139.
3	.320	138.
4	.323	139.
5	.322	138.
6	.323	139.
7	.323	139.
8	.324	139.
9	.323	139.
10	.325	140.
11	.327	140.
12	.326	140.
13	.325	140.
14	.324	139.
15	.322	138.
16	.321	138.
17	.321	138.
18	.320	138.
19	.319	137.
20	.318	137.
21	.317	136.
22	.316	136.
23	.315	135.
24	.315	135.
25	.314	135.
26	.312	134.
27	.310	133.
28	.309	133.
29	.306	131.
30	.305	131.
31	.304	131.
32	.306	131.
33	.304	131.
34	.304	131.
35	.301	129.
36	.299	128.
37	.299	129.
38	.300	129.
39	.300	129.
40	.298	128.
41	.296	127.
42	.292	125.
43	.290	125.
44	.289	124.
45	.289	124.
46	.288	124.
47	.287	123.
48	.286	123.
49	.287	123.
50	.288	124.
51	.288	124.
52	.289	124.
53	.288	124.
54	.287	123.
55	.287	123.
56	.288	124.
57	.289	124.
58	.290	125.
59	.292	125.
60	.291	125.
61	.290	125.
62	.292	125.
63	.292	126.
64	.294	126.
65	.297	128.
66	.299	128.
67	.296	127.

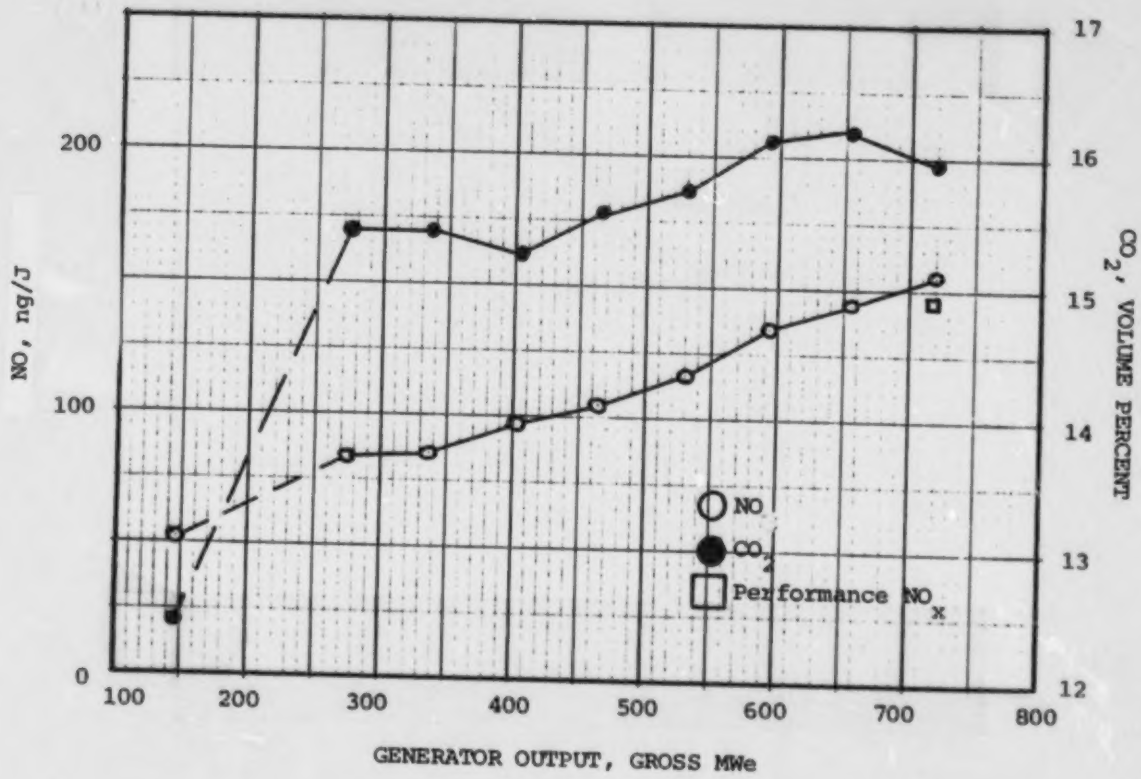


Figure 5-1. Council Bluffs Unit 3 - Boiler Characteristics

5-2

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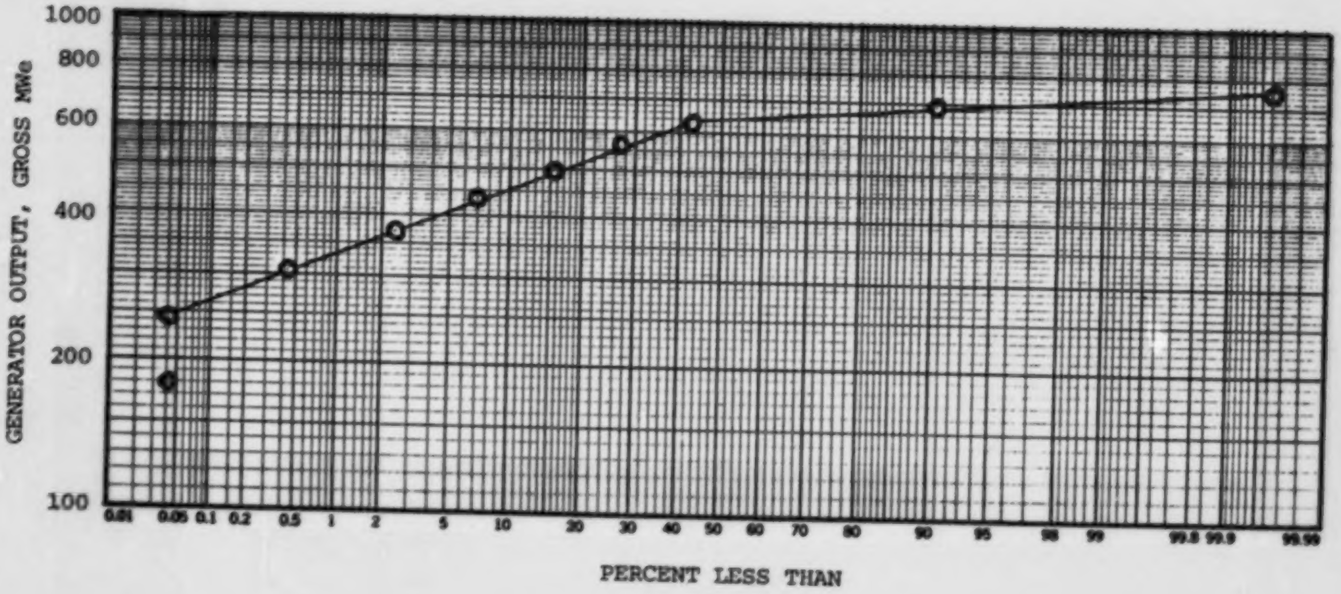

Figure 5-2. Council Bluffs Unit 3 - Load Probability

5-3

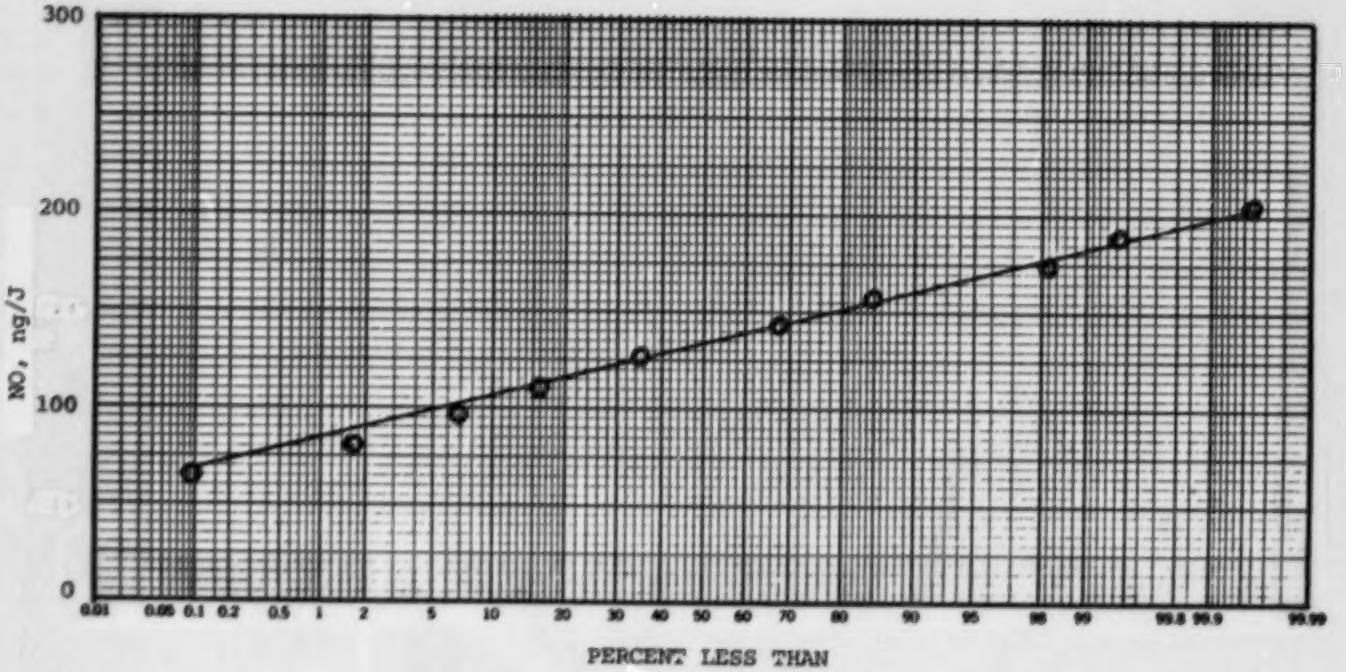

Figure 5-3. Council Bluffs Unit 3 - NO Probability

5-4

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The continuous emission monitor is automatically calibrated once a day, with the results appended to the computer output. KVB examined the daily computer output and, with information obtained during the site visit, determined that 33 days of information were invalid since the NO and/or CO_2 analyzers exceeded their acceptable calibration ranges. The utility has set the acceptable calibration ranges as:

NO - Nominal ± 2.5 percent

CO_2 - Nominal ± 0.5 percent

The NO analyzer was the cause of 31 days (out of 33 days) being deemed invalid.

A revised computer analysis was performed with the invalid days deleted and the summary presented in Table 5-2. The overall results have not changed, i.e., the unit still did not produce any excess emission periods with respect to the 1978 NSPS. Indeed, deleting the 33 days of information had no significant effect on NO versus load, load probability or NO probability as shown in Figures 5-4 through 5-6.

The utility supplied the results of daily coal proximate analyses of moisture, heating value, sulfur and ash for January - May 1981. Table 5-3 summarizes the analysis of the coal samples taken from the conveyor between the stockpile and bunker. (The dry, ash-free heating values were calculated by KVB.) Of note is the relative constancy of all the determinations performed over the five-month period.

These proximate analyses are supported by the ultimate analyses presented in Table 5-4. These analyses confirm the high moisture content and also quantify the difference in heating value between the two mines. Of note are the relatively low values of fuel nitrogen content. (As was determined during the site visit, Eagle Butte supplies 40 percent of the unit's coal requirements.)

The in-situ continuous emission monitor (CEM) was certified during May 8-15, 1979, and the results presented in Tables 5-5 and 5-6 for NO and CO_2, respectively. The CEM is measuring NO only and not NO_x, and no correction is applied to account for NO_2.

(text continued on page 5-26)

TABLE 5-2. REVISED COMPUTER ANALYSIS SUMMARY - COUNCIL BLUFFS UNIT 3

```
                         **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
IOWA POWER AND LIGHT - COUNCIL BLUFFS UNIT 3
***NOTE - CO2 USED FOR DILUTION CORRECTION, NOT O2***
BABCOCK AND WILCOX BOILER WITH DUAL REGISTER BURNERS  720 GROSS MWE
WYOMING SUBBITUMINOUS COAL  NO  MON. REL. ACC. = 9.53PC
DAY 47 = 16 FEBRUARY 1981  ***REVISED ANALYSIS***
PERFORMANCE NOX = 0.34 LB/10**6BTU  (146 NG/J)
```

(continued)

TABLE 5-2. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
47	.347	146.	.0591	25.4	12.5	.01	564.	122.7
50	.304	130.	.0499	19.7	16.3	.30	507.	106.4
[illegible]	.291	121.	[illegible]	27.3	[illegible]	.07	520.	109.3
54	.346	149.	.0526	22.5	15.3	.16	636.	75.4
58	.336	144.	.0398	16.4	15.5	.15	626.	68.5
61	.332	143.	.0492	21.1	15.3	.12	622.	90.9
62	.332	142.	.0337	14.5	15.3	.17	631.	74.5
64	.309	133.	.0708	30.4	15.2	.28	601.	124.3
65	.324	139.	.0510	21.9	15.2	.17	620.	94.7
66	.325	139.	.0527	22.6	15.2	.25	587.	84.5
67	.327	141.	.0187	8.0	15.4	.20	576.	42.5
68	.352	151.	.0530	22.8	15.2	.21	610.	91.9
71	.312	134.	.0457	19.6	15.5	.37	602.	87.4
72	.310	133.	.0617	26.5	15.5	.23	587.	102.3
73	.317	136.	.0533	22.9	15.4	.12	582.	89.1
74	.269	119.	.0593	25.1	15.3	.13	520.	109.1
75	.355	152.	.0448	19.3	15.4	.14	623.	81.0
76	.348	149.	.0463	19.9	15.8	.38	637.	85.0
77	.351	151.	.0601	25.8	15.5	.14	635.	87.0
78	.350	151.	.0356	15.3	15.4	.25	640.	69.1
79	.311	134.	.0597	25.7	15.4	.13	611.	90.9
80	.321	138.	.0472	20.6	15.4	.21	625.	100.5
81	.300	129.	.0343	14.7	15.4	.21	593.	53.7
83	.322	139.	.0519	22.3	15.5	.31	583.	107.8
85	.321	138.	.0586	25.2	16.3	.30	602.	104.9
86	.314	135.	.0501	21.5	16.2	.25	601.	121.0
87	.290	125.	.0236	10.1	16.0	.30	582.	90.7
91	.293	126.	.0364	15.7	15.3	.91	592.	69.6
92	.298	128.	.0330	14.2	16.0	.41	599.	70.7
93	.298	128.	.0341	14.7	16.4	.40	594.	93.5
95	.302	130.	.0210	9.0	15.9	.12	617.	29.0
96	.304	131.	.0257	11.1	16.1	.14	629.	51.3
97	.290	124.	.0332	14.3	16.4	.17	628.	60.0
99	.277	119.	.0392	16.8	16.1	.26	591.	89.7
100	.269	116.	.0399	17.1	16.0	.40	559.	136.3
105	.252	108.	.0303	13.1	16.2	.53	498.	117.9
106	.286	123.	.0398	17.1	16.9	.39	596.	81.3
108	.290	125.	.0466	20.0	17.1	.22	592.	91.3
110	.313	134.	.0092	3.9	17.0	.21	651.	31.0
111	.318	137.	.0109	4.7	16.9	.11	657.	22.4
112	.327	141.	.0130	5.6	16.9	.11	663.	29.1
113	.269	116.	.0450	19.3	16.9	.38	569.	108.7
114	.288	120.	.0333	14.3	17.6	.29	623.	70.3
115	.327	141.	.0349	15.0	16.3	1.02	655.	63.2
116	.332	143.	.0187	8.0	19.3	.19	628.	49.0
117	.309	133.	.0219	9.4	16.4	1.39	624.	51.7
118	.291	125.	.0307	13.2	17.3	.79	611.	55.9
120	.201	86.	.0254	10.9	18.0	.84	603.	90.0
122	.281	121.	.0365	15.7	17.6	.21	612.	88.0
123	.288	124.	.0270	11.6	17.5	.32	616.	77.2
126	.284	122.	.0190	8.1	17.9	.19	602.	80.5
127	.262	113.	.0347	14.9	17.3	.38	567.	100.2
129	.321	138.	.0493	21.2	16.8	1.14	614.	93.7
130	.310	133.	.0120	5.1	17.2	.26	655.	30.9
131	.280	120.	.0116	5.0	17.6	.17	632.	24.2
133	.291	125.	.0288	12.4	17.4	.19	635.	57.6
136	.329	137.	.0205	8.8	17.5	.18	669.	39.1
138	.297	127.	.0134	5.8	17.6	.24	662.	37.8
139	.282	121.	.0278	11.9	17.7	.19	638.	88.1
140	.258	111.	.0493	21.2	17.7	.38	607.	91.0
142	.350	150.	.0669	28.7	15.7	2.02	627.	88.0
144	.375	161.	.0244	10.5	16.1	.11	681.	38.8
148	.364	156.	.0316	13.6	16.9	.28	644.	63.1

(continued)

TABLE 5-2. (CONTINUED)

NO AND CO2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	145.	115.	175.
2	206.	175.	236.
3	266.	236.	296.
4	327.	296.	357.
5	387.	357.	417.
6	448.	417.	478.
7	508.	478.	538.
8	569.	538.	599.
9	629.	599.	659.
10	690.	659.	720.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	CO2 MEAN PERCENT	CO2 STD DEV PERCENT	LOAD PROB. PERCENT
1	1	.120	52.	.0000	.0	12.40	.00	.07
2	0	.000	0.	.0000	.0	.00	.00	.07
3	5	.194	83.	.0182	7.8	15.44	.19	.40
4	30	.194	83.	.0152	6.5	15.85	.79	2.40
5	40	.226	97.	.0383	16.4	15.13	1.48	5.07
6	93	.233	100.	.0265	11.4	15.64	1.00	11.27
7	150	.260	112.	.0257	11.0	15.89	.88	21.28
8	187	.289	124.	.0295	12.7	15.99	1.18	33.76
9	402	.316	136.	.0311	13.3	16.37	1.16	60.57
10	590	.344	148.	.0340	14.6	16.16	1.09	99.93

(continued)

TABLE 5-2. (CONTINUED)

NO PROBABILITY

NO CELL DIMENSIONS

CELL NUMBER	CENTER LB/10**6 BTU	CENTER NG/J	LOWER BOUNDARY LB/10**6 BTU	LOWER BOUNDARY NG/J	UPPER BOUNDARY LB/10**6 BTU	UPPER BOUNDARY NG/J
1	.133	57.	.115	49.	.151	65.
2	.169	73.	.151	65.	.187	80.
3	.205	88.	.187	80.	.223	96.
4	.241	104.	.223	96.	.259	111.
5	.277	119.	.259	111.	.295	127.
6	.313	134.	.295	127.	.331	142.
7	.349	150.	.331	142.	.367	158.
8	.385	165.	.367	158.	.403	173.
9	.421	181.	.403	173.	.439	189.
10	.457	196.	.439	189.	.475	204.

NO PROBABILITY RESULTS

CELL NUMBER	NUMBER OF ENTRIES	CUM. PROB. PERCENT LESS THAN
1	1	.07
2	22	1.53
3	75	6.54
4	149	16.48
5	286	35.56
6	514	69.85
7	253	86.72
8	174	98.33
9	17	99.47
10	7	99.93

(continued)

TABLE 5-2. (CONTINUED)

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                    **NOX COMPLIANCE WITH RESPECT TO 1971 NSPS**

        FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)

         FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)

   FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)

        FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)

                     THIS BOILER WAS OPERATED WITH SUBBITUMINOUS COAL

          THE NOX MEASURED DURING THE PERFORMANCE TEST WAS   .340  LB/10**6 BTU (146. NG/J)

AN ANALYSIS OF 3-HOUR NO  ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)

              INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON      0  OCCASIONS

AN ANALYSIS OF 3-HOUR NO  BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)

              INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON      0  OCCASIONS
```

(continued)

TABLE 5-2.   (CONTINUED)

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                **NOX COMPLIANCE WITH RESPECT TO 1978 NSPS**

                     1978 NSPS NOX EMISSION LIMITATIONS
            SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
              BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
  LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
              OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)


  ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED     0  EXCEEDANCES

                         30-DAY ROLLING AVERAGES
          EMISSION LIMITATION   .50 LB/10**6 BTU  215. NG/J

           SEQUENTIAL              30-DAY AVERAGE NO
            AVERAGE                LB/10**6 BTU  NG/J
           ==========              ============  ====
                1                      .320      138.
                2                      .317      136.
                3                      .317      136.
                4                      .318      137.
                5                      .316      136.
                6                      .313      135.
                7                      .310      133.
                8                      .308      133.
                9                      .308      132.
               10                      .307      132.
               11                      .307      132.
               12                      .307      132.
               13                      .304      131.
               14                      .303      130.
               15                      .304      131.
               16                      .304      131.
               17                      .306      131.
               18                      .304      130.
               19                      .299      128.
               20                      .297      127.
               21                      .295      127.
               22                      .294      126.
               23                      .292      125.
               24                      .293      126.
               25                      .292      125.
               26                      .291      125.
               27                      .290      125.
               28                      .291      125.
               29                      .291      125.
               30                      .291      125.
               31                      .290      125.
               32                      .292      125.
               33                      .294      126.
               34                      .296      127.
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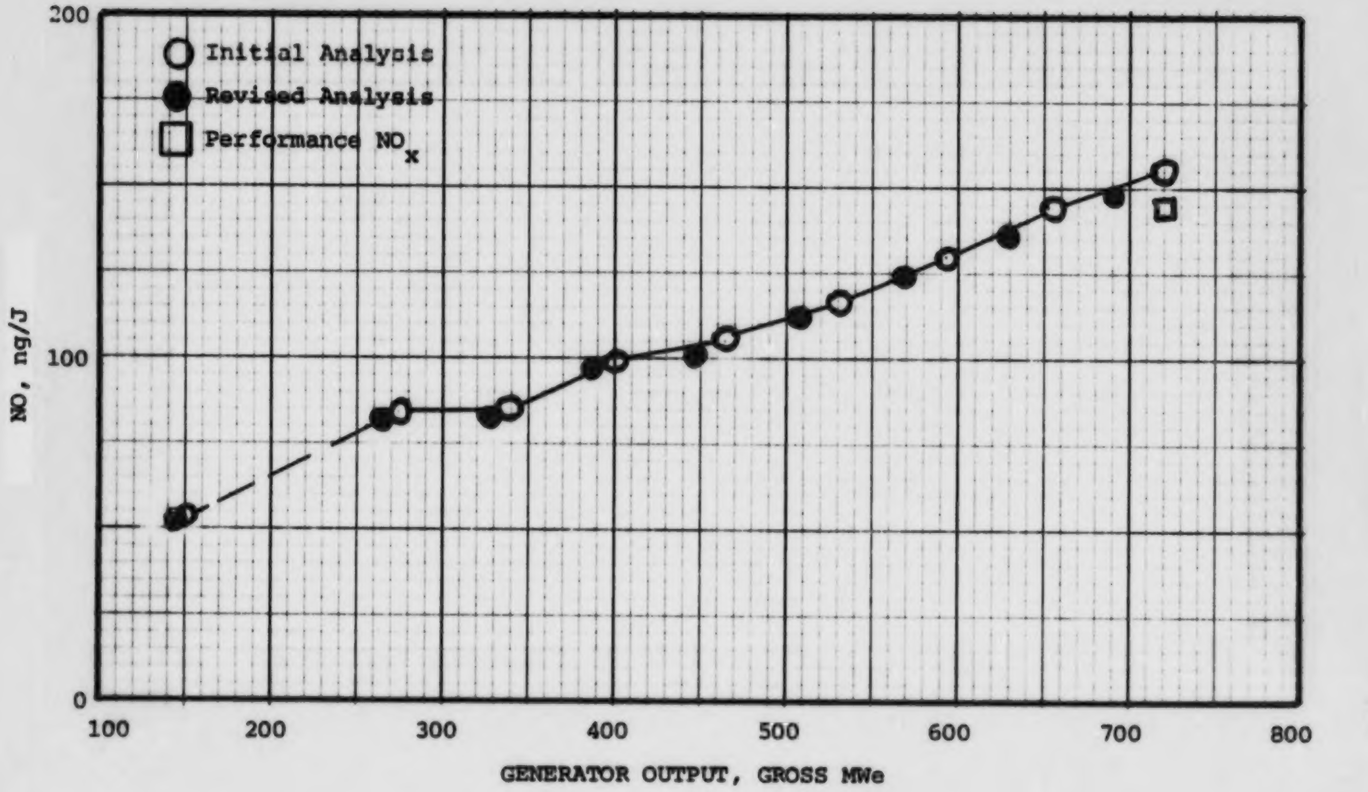

Figure 5-4. Council Bluffs Unit 3 - NO Comparison

5-6

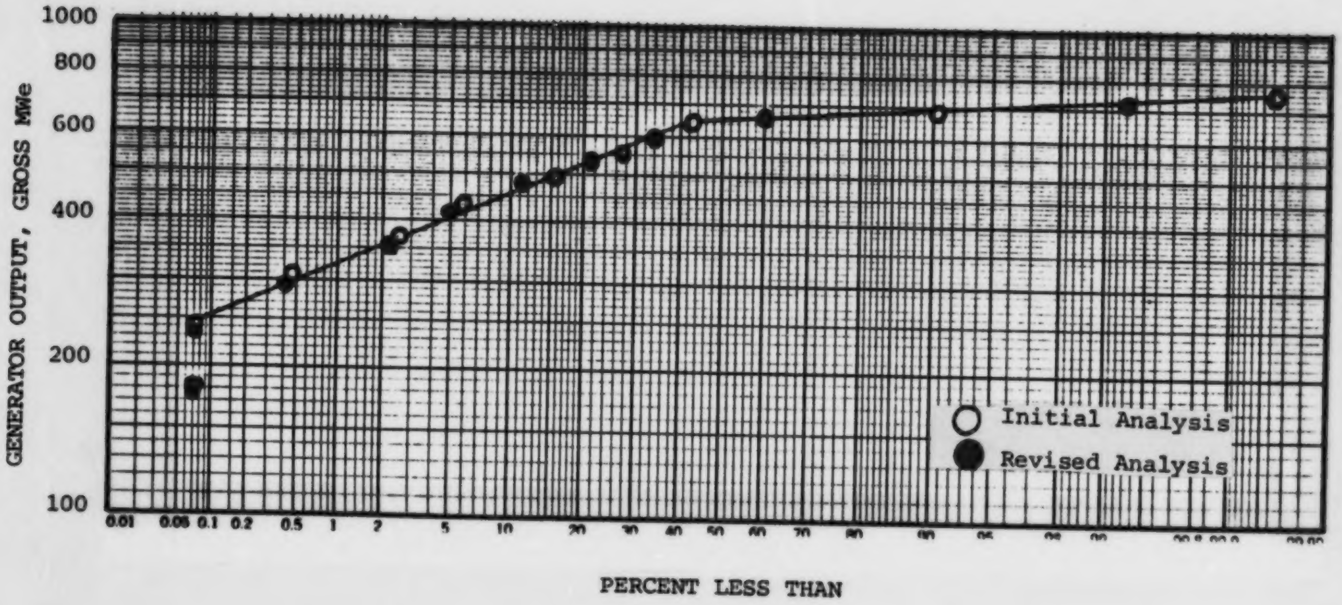

Figure 5-5. Council Bluffs Unit 3 - Load Probability Comparison

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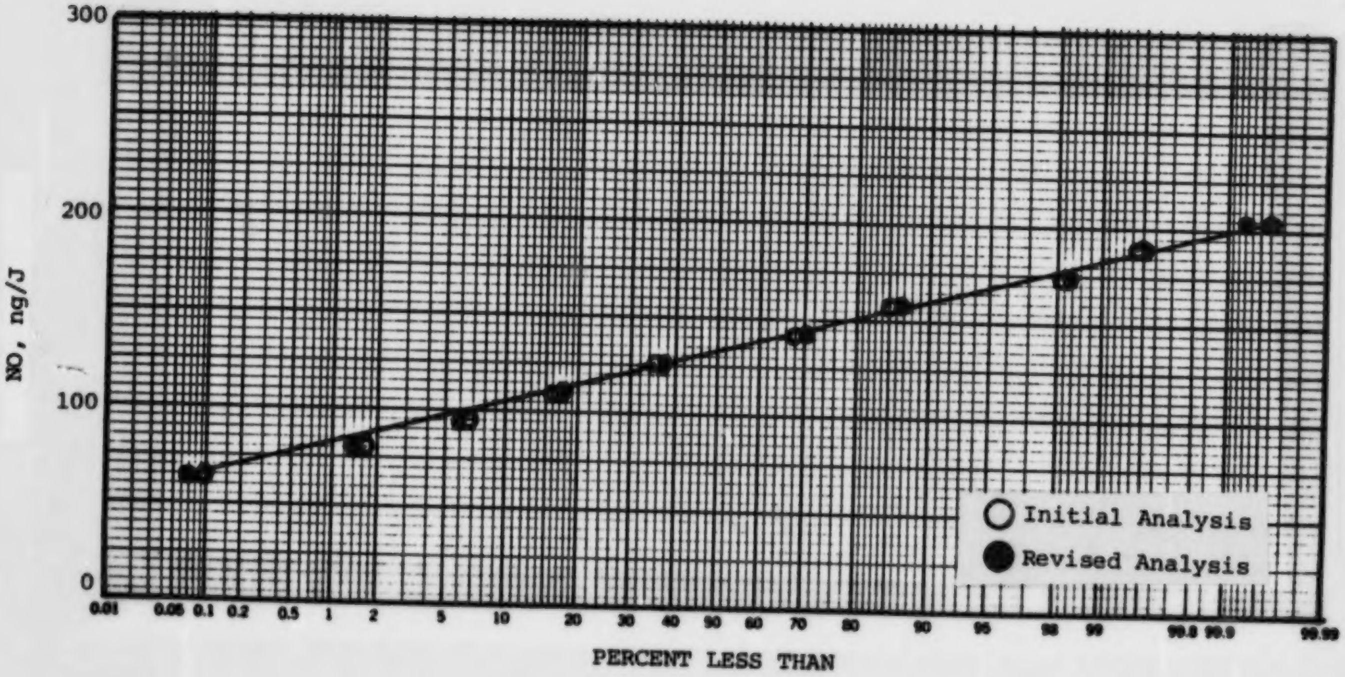

Figure 5-6. Council Bluffs Unit 3 - NO Probability Comparison

5-8

TABLE 5-3. COAL PROXIMATE ANALYSES - COUNCIL BLUFFS UNIT 3

(Monthly Averages for 1981)

Parameter	Jan.	Feb.	March	April	May	Jan.-May
Number of Samples	31	28	31	30	31	151
Moisture	30.36	30.21	30.32	29.71	29.74	30.07
Heating Value						
Btu/lb	8,312	8,327	8,313	8,375	8,297	8,324
kJ/kg	19,334	19,369	19,336	19,480	19,299	19,362
Sulfur	0.33	0.34	0.35	0.32	0.33	0.33
Ash	4.84	4.83	4.65	4.68	4.95	4.79
Heating Value-Dry, Ash-Free						
Btu/lb	12,827	12,819	12,783	12,765	12,704	12,779
kJ/kg	29,836	29,817	29,733	29,691	29,550	29,724

TABLE 5-4. COAL ULTIMATE ANALYSES - COUNCIL BLUFFS UNIT 3

	Eagle Butte Mine		Belle Ayre Mine*	
	As Received	Dry Basis	As Received	Dry Basis
Moisture	31.32	-	28.25	-
Carbon	47.11	68.60	49.69	69.25
Hydrogen	3.32	4.83	3.72	5.18
Nitrogen	0.57	0.83	0.64	0.89
Chlorine	0.02	0.03	0.05	0.07
Sulfur	0.35	0.51	0.46	0.64
Ash	4.64	6.76	5.46	7.61
Oxygen (by difference)	12.67	18.44	11.76	16.39
Btu/lb	8,113	11,813	8,643	12,046
kJ/kg	18,871	27,477	20,104	28,019

*Average of 4 analyses

TABLE 5-5. NO ANALYZER CERTIFICATION TEST RESULTS - COUNCIL BLUFFS UNIT 3

Parameter	EPA Specification	Test Result
Relative Accuracy	≤ 20%	9.53%
Zero Drift (2-hr)	≤ 2% of span	*
Zero Drift (24-hr)	≤ 2% of span	*
Calibration Drift (2-hr)	≤ 2% of span	0.34%
Calibration Drift (24-hr)	≤ 2.5% of span	0.72%
Calibration Error	≤ 5% (mid-range)	1.98%
	≤ 5% (high-range)	0.91%
Response Time	15 min. maximum	0.04 min.
Operational Period	168 hr. minimum	168 hr.

*Zero drift can't be simulated. Earlier models of this analyzer had no provision to simulate a zero gas condition. Later models were equipped with a gas pipe and air purge to simulate zero gas. EPA has waivered zero drift requirements.

TABLE 5-6. CO_2 ANALYZER CERTIFICATION TEST RESULTS -
COUNCIL BLUFFS UNIT 3

Parameter	EPA Specification	Test Result
Relative Accuracy	None	7.7%
Zero Drift (2-hr)	$\leq$ 0.4% of CO_2	*
Zero Drift (24-hr)	$\leq$ 0.5% CO_2	*
Calibration Drift (2-hr)	$\leq$ 0.4% CO_2	0%
Calibration Drift (24-hr)	$\leq$ 0.5% CO_2	0%
Response Time	10 min. maximum	0.10 min.
Operational Period	168 hr. minimum	168 hr.

*Zero drift can't be simulated. Earlier models of this analyzer had no provision to simulate a zero gas condition. Later models were equipped with a gas pipe and air purge to simulate zero gas. EPA has waivered zero drift requirements.

The hourly-averaged computer input data for both the initial and revised analyses is contained in Appendices G and H, respectively.

5.2 SITE VISIT

On September 11, 1981, a meeting was held with Mr. Jim Woodworth, Results Engineer, and other station personnel to discuss boiler operation.

5.2.1 Boiler Design

- Boiler manufacturer is Babcock & Wilcox.
- Opposed face-fired with 56 dual register burners:
    - 4 rows of 8 burners each on front face
    - 3 rows of 8 burners each on rear face
- Furnace heat release rate is 10,500 Btu/hr-ft^3 at rated capacity.
- Wyoming subbituminous coal.
- Generator rated at 720 MWe gross.

5.2.2 Operational Items

- O_2 Operation: The boiler is induced draft fan limited at high load. As a result careful attention is paid to maintain the operating O_2 at low levels both because of the ID fan limitation and also in the interest of fuel efficiency. The boiler operators are provided with a CO monitor so that minimum air operation can be implemented. The monitor is measuring CO in the stack. In addition, an O_2 trim control is provided using permanently installed probes in the economizer outlet. Typically, the O_2 is 2.5-3 percent at high load and ~6 percent at 40 percent load.

- Heat Rate: The heat rate, based on design specifications is 9,981 Btu/kWh gross. The operating heat rate is computed and printed on an hourly, daily and monthly averaged basis.

- Steam Temperature: The boiler has experienced no problems in maintaining the design steam temperatures of 1,000/1,000°F (811K). Primary superheat area had to be removed as the boiler was too "hot." Spraying is required at nearly all loads.

- Burner Operation: The utility had performed an extensive program to balance the O_2 across the boiler. As a result, all burner registers have been set at:

  Inner Registers - 100 percent open
  Spin Vanes - 20-30 percent open
  Outer Registers - 30-40 percent open

  These register settings are not changed with load.

- Slagging/Fouling: The utility has found that operation at too low an O_2 at high load can cause a slag bridge to form across the superheater tubes. Low load night-time operation in conjunction with sootblowing usually dislodges the slag.

- Unit Load Limitation: Any air heater pluggage or precipitator leakage aggravates the ID fan limitation. On occasion this has limited the boiler to approximately 700 MWe gross.

- Ash Carbon Characteristics: The flyash is sold to cement kiln operators who periodically test for flyash carbon content. The average carbon content measured was 0.4 percent with a maximum of 1.4 percent.

- Tube Wastage: None determined.

- NO Emissions Excursions: The analysis of the emissions data indicated no periods of excess emissions.

Maintenance of the Iowa Power and Light Council Bluffs Unit 3 CEM is done by the monitor manufacturer under a service contract. (The station personnel do not perform any maintenance duties associated with the gaseous monitor. However, they do maintain the opacity monitor.) Therefore, on August 14, 1981 a telephone conversation was held with Mr. Dana Shay (Thermo Electron/EDC) who is on-call for monitor maintenance. The following information was obtained during the conversation:

5.2.3 Continuous Emissions Monitoring System

- Make and Model: The CEM is a 1400 series package manufactured by EDC and measures CO, CO_2, SO_2, and NO, and includes a Contraves opacity meter. The CO channel was installed during December 1980 to mid-February 1981 during which time the CO_2 channel was out-of-service. The in situ monitor is measuring NO only and not NO_x.

  The CEM is temperature controlled to 90°F (306K) by the use of insulation, a heater, a cooling fan and appropriate control circuits.

- Monitor Certification Date: May 8-15, 1979

- CEM Location: The CEM is at the 300 ft. level (91.5m) on the stack and is after the air heater and hot-side ESP.

- Measurement Differences - CEM/Boiler: There is no measurement on which to assess O_2 or CO_2 differences between the CEM location and boiler.

- CEM Data Reduction: The CEM output is on strip-charts with the monitor computer integrating for hourly averages. The monitor is certified through the computer. The EPA "F" factor of 1810 scf $CO_2/10^6$ Btu is used in the data reduction.

- Monitor Certification: The original certification showed that the NO relative accuracy was 9.5 percent. The relative accuracy has not been redetermined since the original certification.

- Calibration Procedure:

  (1) Description - The CEM uses a sealed cell containing known amounts of CO_2 and NO which is inserted into the optical path.

  (2) Operation - The CEM is auto-calibrated once a day. Mr. Shay indicated that if certain calibration parameters are exceeded then a notation is made on the computer output. Mr. Shay was not familiar with the values which would cause an out-of-specification notation.* (The discussion presented in Section 5.1 indicated that the calibration results are printed everyday. A plant technician then determines if the calibration is out-of-specification.)

- Quality Assurance Procedures: There is no written quality assurance program (as none is required by regulation). As previously mentioned there are no station personnel assigned for monitor maintenance or calibration.

- CEM Operation and Availability History: The only measure of CEM operation and availability is the number of times Mr. Shay was called to the station to service the CEM. Between January and August 1981, Mr. Shay and his associate have made five service calls to recalibrate the monitor.

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*These values were subsequently provided by the utility and are enumerated on page 5-12.

5.2.4 Coal Supply

- The AMAX Eagle Butte and Belle Ayre mines in Gillette, Wyoming provide the coal with Eagle Butte supplying 40 percent of the total.

5.2.5 Flue Gas Desulfurization and Particulate Control

- The unit is not equipped with a FGD system and uses a hot-side ESP for particulate control.

SECTION 6.0

PENNSYLVANIA ELECTRIC COMPANY-HOMER CITY GENERATING STATION, UNIT 3

6.1 EMISSIONS ANALYSIS

Data supplied for this unit was for the 92-day period of May, June and July, 1979. This period corresponds to a maximum of 2,208 hours of data. However, only 1,458 hours (66.0 percent) of data were used in the analysis and the difference was due primarily to:

1. Boiler outages - 10 days
2. Monitor outages - 7 days
3. Invalid O_2 readings as indicated by outside vendor - 11 days

Monitor reliability, defined as the ratio of the monitor operating hours to boiler operating hours, was calculated to be 85.6 percent. It is uncertain why the outside vendor indicated that 11 days of O_2 readings were invalid. However, these days were not counted in the calculation of monitor reliability.

The computer analysis is summarized in Table 6-1 with the complete input data presented in Appendix I. As noted from the load probability results, the unit is base-loaded, i.e., 85 percent of the hourly-averaged loads were above 642 MWe (above 94 percent of rated generator output). The effect of base-loading is also reflected in the near constancy of the 30-day rolling averages.

Figure 6-1 is a plot of the boiler characteristics of NO and O_2 versus load. Insufficient data was available to fully characterize these characteristics below loads of 376 MWe gross. The NO at high load is in close agreement with the value measured during the performance test required by the 1971 NSPS.

The NO probablity is shown in Figure 6-2 in log-normal coordinates. It was determined that the geometric mean was 280 ng/J and the geometric

(text continued on page 6-10)

TABLE 6-1. COMPUTER ANALYSIS SUMMARY - HOMER CITY UNIT 3

```
                    **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
PENNSYLVANIA ELECTRIC HOMER CITY STATION UNIT 3

B+W BOILER OPPOSED FACE-FIRED

680 MWE GROSS          DAY 1 = 1 MAY 1979

DUAL REGISTER BURNERS   BITUMINOUS COAL

NO  MONITOR RELATIVE ACCURACY = 12.4 PC

PERFORMANCE TEST NOX = 0.68 LB/10**6 BTU, 292 NG/J
```

(continued)

TABLE 6-1. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
1	.555	238.	.0302	13.0	6.6	.08	651.	2.8
2	.557	239.	.0222	9.5	6.4	.23	650.	3.9
3	.628	270.	.0284	12.2	7.2	.57	604.	60.1
4	.660	284.	.0202	8.7	7.1	.10	652.	1.8
5	.684	294.	.0336	14.4	7.0	.07	651.	13.6
6	.663	285.	.0300	12.9	7.0	.09	656.	4.4
7	.625	268.	.0219	9.4	7.1	.13	648.	8.8
8	.601	258.	.0034	1.5	7.0	.08	647.	3.5
9	.596	256.	.0141	6.1	7.0	.08	647.	3.1
10	.601	258.	.0088	3.8	7.0	.08	647.	3.8
16	.645	277.	.0262	11.3	6.7	.15	657.	10.3
17	.660	284.	.0320	13.8	6.7	.27	657.	2.5
18	.637	274.	.0158	6.8	6.6	.28	657.	2.8
19	.633	272.	.0113	4.9	6.6	.16	656.	1.8
20	.614	264.	.0273	11.7	6.6	.12	655.	2.0
21	.618	266.	.0267	11.5	6.6	.36	654.	2.5
22	.627	269.	.0394	16.9	6.6	.12	657.	3.3
23	.610	262.	.0227	9.7	6.7	.30	654.	2.5
24	.638	274.	.0196	8.4	6.8	.13	654.	3.0
25	.642	276.	.0044	1.9	6.8	.11	657.	2.6
26	.645	277.	.0128	5.5	6.9	.16	628.	22.3
27	.647	278.	.0330	14.2	7.1	.08	509.	86.8
30	.650	279.	.0000	.0	7.0	.00	656.	3.5
31	.664	285.	.0357	15.4	7.0	.10	652.	11.2
32	.648	279.	.0084	3.6	6.9	.11	654.	4.7
44	.685	294.	.0169	7.3	6.5	.05	656.	2.7
45	.677	291.	.0246	10.6	6.5	.07	653.	2.2
46	.666	286.	.0297	12.8	6.5	.10	651.	1.7
47	.687	295.	.0183	7.9	6.3	.10	653.	2.0
48	.666	286.	.0286	12.3	6.2	.19	654.	3.0
49	.675	290.	.0184	7.9	6.1	.15	653.	3.8
50	.688	296.	.0215	9.2	6.3	.05	654.	1.9
51	.685	294.	.0372	16.0	6.0	.34	653.	2.7
52	.654	281.	.0252	10.8	5.9	.13	651.	2.9
62	.680	292.	.0316	13.6	6.0	.19	655.	10.0
63	.657	282.	.0275	11.8	6.0	.14	659.	2.3
64	.702	302.	.0354	15.2	6.2	.36	657.	13.5
65	.717	308.	.0477	20.5	6.7	.30	648.	13.0
66	.670	288.	.0494	21.2	6.8	.41	622.	50.2
67	.745	320.	.0341	14.7	7.0	.39	629.	67.3
68	.744	320.	.0532	22.8	6.6	.13	655.	10.0
69	.687	295.	.0070	3.0	6.4	.14	657.	2.1
70	.677	291.	.0307	13.2	6.9	.18	656.	2.8
71	.653	280.	.0125	5.4	6.7	.08	655.	2.7
72	.634	272.	.0295	12.7	6.8	.14	633.	27.0
73	.636	273.	.0118	5.1	6.6	.18	653.	2.6
74	.622	267.	.0122	5.2	6.6	.13	653.	3.3
75	.612	263.	.0280	12.0	6.3	.12	635.	19.8
76	.585	251.	.0232	10.0	6.3	.08	616.	4.2
77	.595	256.	.0234	10.1	6.3	.11	651.	6.0
78	.612	263.	.0236	10.2	6.4	.12	654.	2.0
79	.620	266.	.0174	7.5	6.4	.12	655.	2.6
80	.628	270.	.0042	1.8	6.4	.11	653.	2.0
82	.674	290.	.0884	38.0	6.0	2.35	567.	181.1
83	.697	300.	.0221	9.5	5.8	.10	655.	2.7
84	.704	302.	.0309	13.3	5.8	.13	661.	11.1
88	.694	298.	.0316	13.6	6.4	.13	654.	3.4
89	.688	296.	.0283	12.2	6.3	.10	649.	10.2
90	.686	295.	.0128	5.5	6.3	.16	646.	8.6
91	.697	298.	.0240	10.3	6.4	.13	650.	4.2
92	.687	295.	.0143	6.2	6.4	.13	658.	6.3

(continued)

TABLE 6-1. (CONTINUED)

NO AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	78.	45.	111.
2	144.	111.	178.
3	211.	178.	244.
4	277.	244.	310.
5	343.	310.	376.
6	410.	376.	443.
7	476.	443.	509.
8	542.	509.	575.
9	609.	575.	642.
10	675.	642.	708.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD PROB. PERCENT
1	1	.410	176.	.0000	.0	14.50	.00	.07
2	1	.570	245.	.0000	.0	12.00	.00	.14
3	0	.000	0.	.0000	.0	.00	.00	.14
4	1	.490	210.	.0000	.0	9.00	.00	.21
5	0	.000	0.	.0000	.0	.00	.00	.21
6	8	.651	280.	.0653	28.1	7.78	.47	.75
7	54	.564	242.	.0366	15.7	8.13	.30	4.46
8	9	.636	273.	.0536	23.0	7.06	.54	5.07
9	133	.653	281.	.0625	26.9	6.64	.37	14.19
10	1251	.667	288.	.0422	18.1	6.53	.38	90.93

(continued)

TABLE 6-1. (CONTINUED)

NO PROBABILITY

NO CELL DIMENSIONS

CELL NUMBER	CENTER LB/10**6 BTU	CENTER NG/J	LOWER BOUNDARY LB/10**6 BTU	LOWER BOUNDARY NG/J	UPPER BOUNDARY LB/10**6 BTU	UPPER BOUNDARY NG/J
1	.426	183.	.405	174.	.447	192.
2	.468	201.	.447	192.	.489	210.
3	.510	219.	.489	210.	.531	228.
4	.552	237.	.531	228.	.573	246.
5	.594	255.	.573	246.	.615	264.
6	.636	273.	.615	264.	.657	282.
7	.678	291.	.657	282.	.699	300.
8	.720	309.	.699	300.	.741	318.
9	.762	327.	.741	318.	.783	336.
10	.804	345.	.783	336.	.825	354.

NO PROBABILITY RESULTS

CELL NUMBER	NUMBER OF ENTRIES	CUM. PROB. PERCENT LESS THAN
1	1	.07
2	0	.07
3	19	1.37
4	56	5.21
5	195	18.57
6	556	56.68
7	430	86.15
8	143	95.96
9	50	99.38
10	8	99.93

(continued)

TABLE 6-1. (CONTINUED)

NOX COMPLIANCE WITH RESPECT TO 1971 NSPS

FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)

FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)

FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)

FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)

THIS BOILER WAS OPERATED WITH BITUMINOUS COAL

THE NOX MEASURED DURING THE PERFORMANCE TEST WAS .680 LB/10**6 BTU (292. NG/J)

AN ANALYSIS OF 3-HOUR NO ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)

INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON 161 OCCASIONS

AN ANALYSIS OF 3-HOUR NO BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)

INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON 60 OCCASIONS

(continued)

TABLE 6-1.   (CONTINUED)

```
                **NOX COMPLIANCE WITH RESPECT TO 1978 NSPS**

                     1978 NSPS NOX EMISSION LIMITATIONS
             SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
               BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
  LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
               OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)


   ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED   32  EXCEEDANCES

                       30-DAY ROLLING AVERAGES
           EMISSION LIMITATION  .60 LB/10**6 BTU  258. NG/J

              SEQUENTIAL            30-DAY AVERAGE NO
               AVERAGE              LB/10**6 BTU  NG/J
              ==========            ============  ====
                   1                    .637      274.
                   2                    .641      275.
                   3                    .646      277.
                   4                    .647      278.
                   5                    .647      278.
                   6                    .647      278.
                   7                    .647      278.
                   8                    .650      279.
                   9                    .653      281.
                  10                    .656      282.
                  11                    .661      284.
                  12                    .664      285.
                  13                    .665      286.
                  14                    .667      286.
                  15                    .667      287.
                  16                    .668      287.
                  17                    .668      287.
                  18                    .668      287.
                  19                    .668      287.
                  20                    .667      286.
                  21                    .665      286.
                  22                    .664      285.
                  23                    .663      285.
                  24                    .663      285.
                  25                    .663      285.
                  26                    .665      285.
                  27                    .665      286.
                  28                    .666      286.
                  29                    .667      286.
                  30                    .667      286.
                  31                    .668      287.
                  32                    .668      287.
```

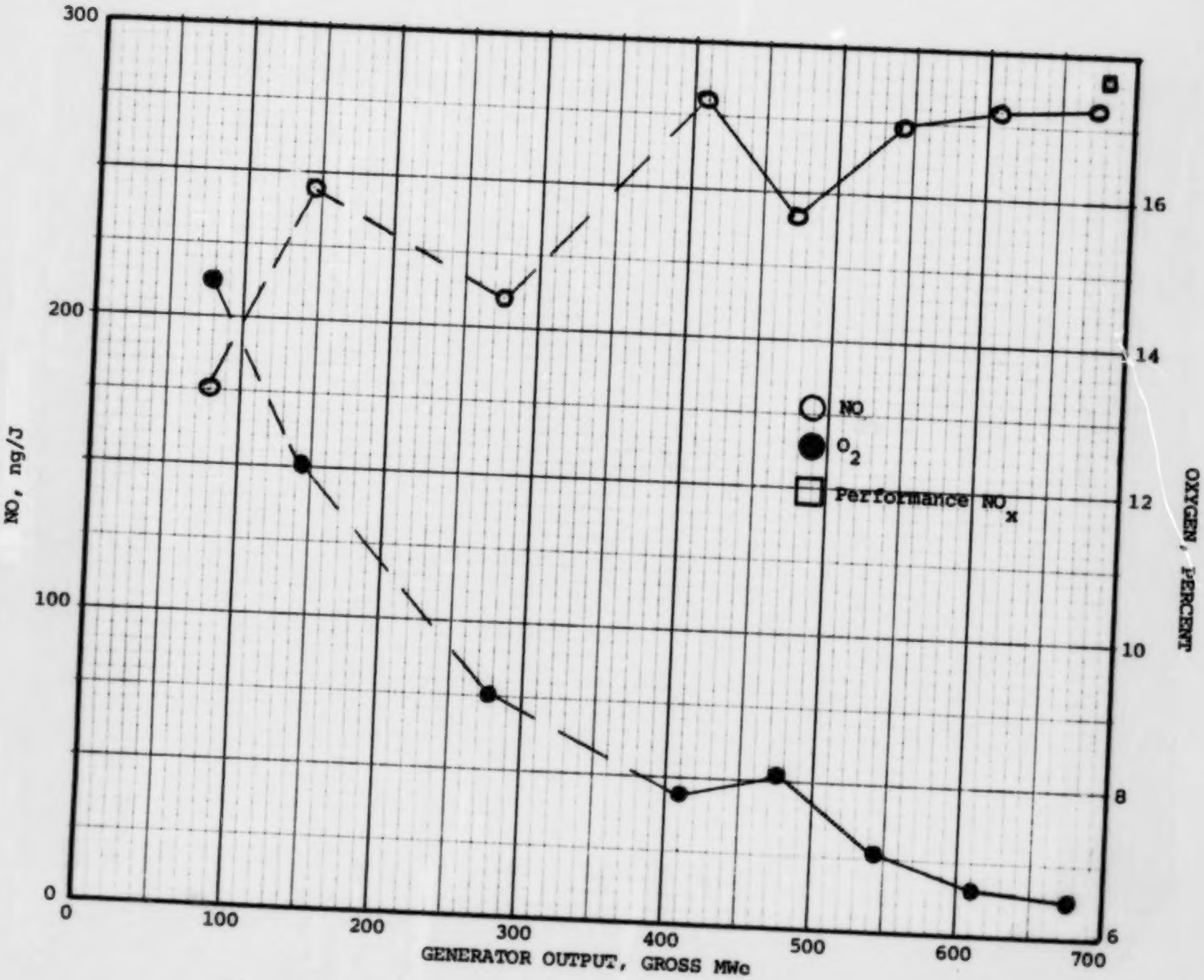

Figure 6-1. Homer City Unit 3 - Boiler Characteristics

6-2

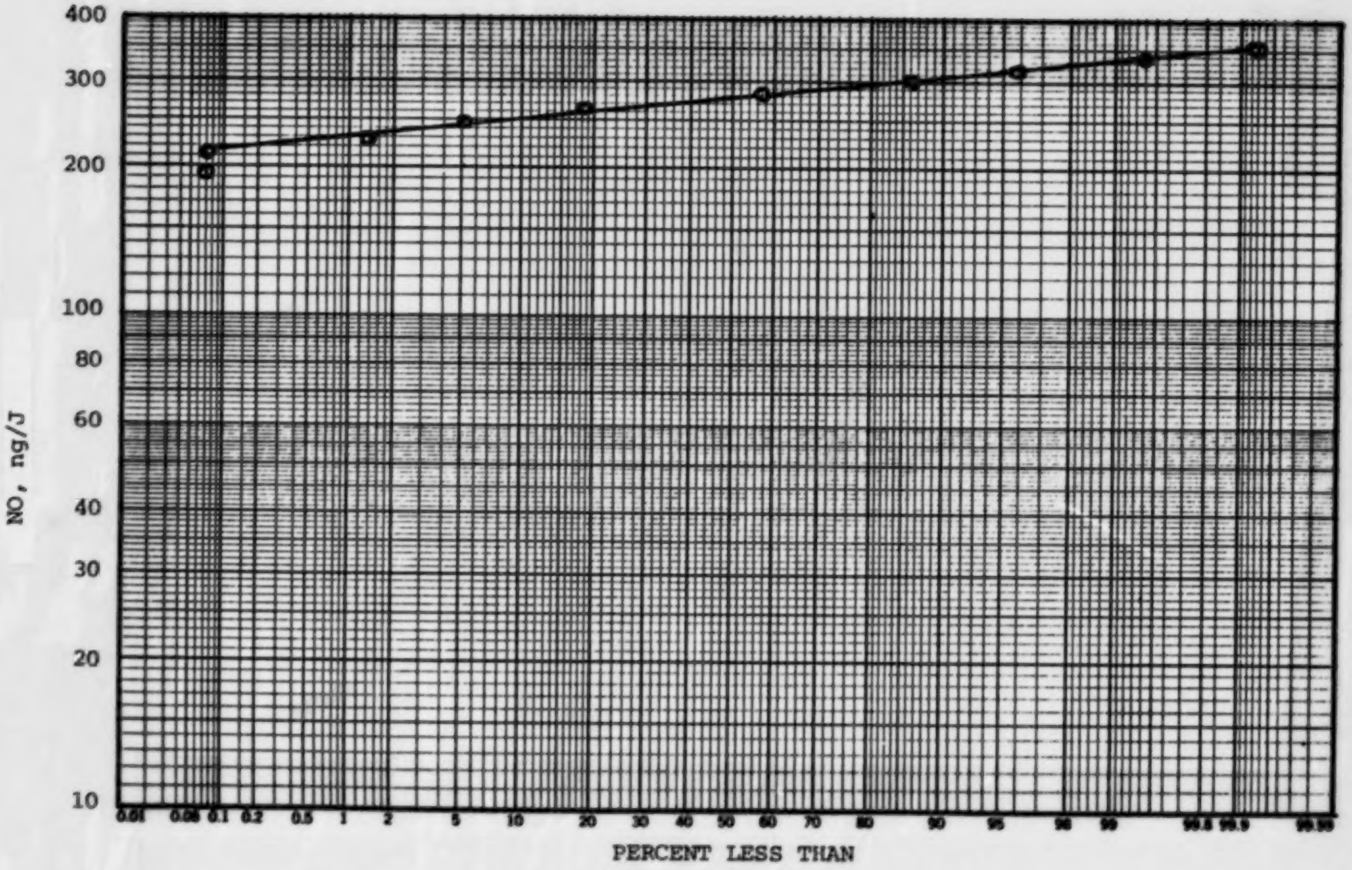

Figure 6-2. Homer City Unit 3 - NO Probability

dispersion was 1.08. The base-loaded operation of the unit is reflected in the load probability (Figure 6-3) which, in turn, explains the low geometric dispersion in NO, i.e., the bulk of the NO measurements were obtained when the unit was running essentially at constant load.

With respect to the 1971 NSPS this unit experienced 161 exceedances (out of a maximum of 1456) on a 3-hour rolling average and 60 exceedances (out of a maximum of 486) on a 3-hour block average. This result demonstrates the potentially significant difference in excess emissions due to the averaging method employed.

This unit, had it been subject to the 1978 NSPS, would not have complied with the NO performance test for bituminous coal. In addition, all 30-day rolling averages would have been periods of excess emission. These results are probably due to unit operation under base-loaded conditions.

The coal used by Unit 3 is a blend of physically cleaned coal (PCC) and run-of-mine coal. The PCC facility at Homer City removes pyritic sulfur from a feed coal with a 3-3.5 percent sulfur content. A total of 74 as-fired coal proximate analyses were supplied for the May - July, 1979 time period. These analyses consisted of heating value and sulfur content determinations only. Table 6-2 summarizes these analyses in terms of the means and standard deviations on a monthly and overall basis, wherein it is noted that the mean heating value changed by 4.3 percent and the mean sulfur content changed by 14.4 percent from May to July. It is not possible, according to Reference 3, to make a definitive assessment of coal property constancy based on heating value and sulfur content alone. Coal moisture content is the single largest variable and it must be quantified in order to verify coal property constancy.

The Lear Siegler SM810 SO_2/NO analyzer and CM50 O_2 analyzer were certified between March 27 and April 11, 1979. Tables 6-3 and 6-4 present the results of the certification.

6.2 SITE VISIT

On June 30, 1981 a meeting was held with Mr. Jim Rudd, Environmental Monitoring System Group Supervisor, to discuss monitor operation. The data

(text continued on page 6-15)

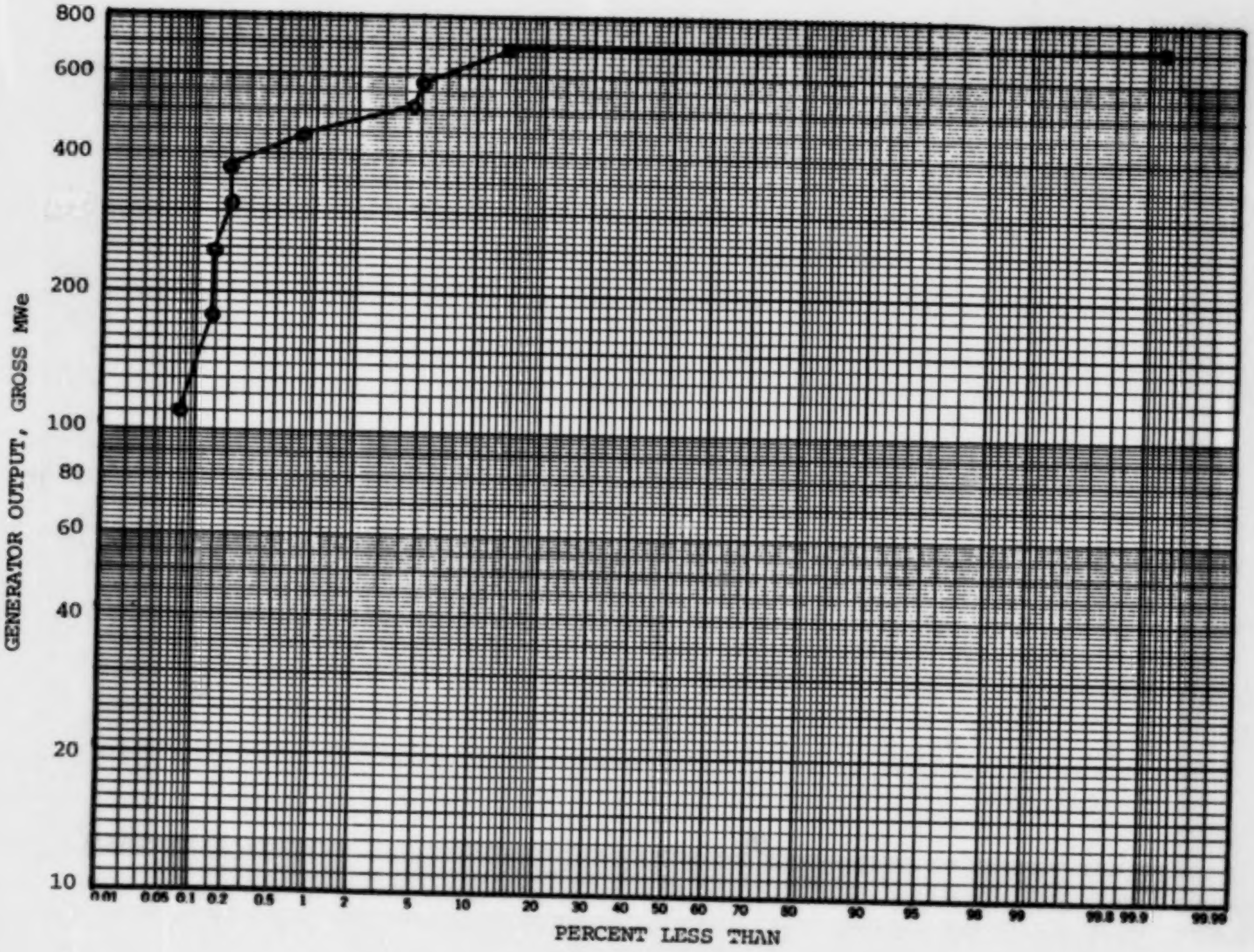

Figure 6-3. Homer City Unit 3 - Load Probability

6-4

TABLE 6-2. HOMER CITY UNIT 3 AS-FIRED COAL PROXIMATE ANALYSES

Parameter	1979			
	May	June	July	May-July
Sample Size	18	27	29	74
Mean Heating Value				
Btu/lb	11,890	12,180	12,400	12,200
kJ/kg	27,650	28,340	28,850	28,370
Heating Value Stand. Dev.				
Btu/lb	210	230	190	290
kJ/kg	500	540	450	680
Mean Sulfur Content, %	2.02	1.94	1.73	1.88
Sulfur Content Stand. Dev., %	0.22	0.17	0.37	0.30

TABLE 6-3. NO ANALYZER CERTIFICATION RESULTS--
HOMER CITY UNIT 3

Parameter	EPA Specification	Result
Relative Accuracy	≤20%	12.4%
Calibration Error	≤5%	1.6% (mid-range) 4.1% (high-range)
Zero Drift (2-hour)	≤2% of span	0.4%
Zero Drift (24-hour)	≤2% of span	1.0%
Calibration Drift (2-hour)	≤2% of span	0.4%
Calibration Drift (24-hour)	≤2.5% of span	0.57%
Response Time	15 minute maximum	2.4 min.
Operational Period	168 hour minimum	384 hr.

TABLE 6-4. O_2 ANALYZER CERTIFICATION RESULTS--HOMER CITY UNIT 3

Parameter	EPA Specification	Result
Zero Drift (2-hour)	$\leq$0.4% O_2	0.02% O_2
Zero Drift (24-hour)	$\leq$0.5% O_2	0.1% O_2
Calibration Drift (2-hour)	$\leq$0.4% O_2	0.08% O_2
Calibration Drift (24-hour)	$\leq$0.5% O_2	0.35% O_2
Response Time	10 minute maximum	0.18 min.
Operational Period	168 hour minimum	384 hr.*

*Not explicitly stated and assumed the same as NO instrument.

supplied on this unit indicated that it is base-loaded, i.e., over 85 percent of the hourly-averages were at or above 90 percent of rated generator output. Unit 3 is the newest and most efficient at the generating station and is, therefore, heavily loaded. A brief telephone conversation was also held with Mr. Steven Poje, Technical Supervisor, to discuss boiler operation.

6.2.1 Boiler Design

- Boiler manufacturer is Babcock and Wilcox.
- Opposed-face fired.
- 48 dual register burners. Three rows of 8 burners each face.
- Coal is a blend of physically cleaned coal and run-of-mine coal.
- Furnace heat release rate is 11,500 Btu/hr-ft^3.
- Generator output is 680 gross MWe.

6.2.2 Operational Items

- With 6 mills in service design excess air is 20 percent at full load and 47 percent excess air at 20 percent load. Air flow to burners is controlled by secondary air dampers.

- Heat Rate: Unit 3--9,500 - 9,600 Btu/kWh. Units 1 and 2 have heat rates of 10,100 Btu/kWh.

- Steam Temperature: The unit has not encountered any superheat temperature problems.

- Slagging/Fouling Characteristics: Mr. Poje indicated that Unit 3 has experienced far less slagging than Units 1 and 2, possibly because Unit 3 is using a "cleaner" coal, i.e., lower sulfur content.

- Unit Load Limit: Unit 3 has no load limitations.

- Ash Carbon Characteristics: In the fall of 1980, B&W performed a boiler performance evaluation and analyzed five fly ash samples. The results were 2.3, 3.1, 2.3, 0.6, and 1.0 percent unburned carbon.

- Tube Wastage: Unit 3 has experienced tube erosion due to inadequate water traps in the steam sootblowing system.

6.2.3 Continuous Emissions Monitoring System

- Make and Model: Lear Siegler Model CM50 O_2 analyzer and Model SM810 NO/SO_2 analyzer. The SM810 is measuring NO only and not total NO_x. No correction is made to account for NO_2.

- Monitor Certification Date: March 27 - April 11, 1979
- CEM Location: The monitor is located after the air heater at the 319 ft. elevation on the stack.
- Oxygen Analyzer; CEM/Boiler: Leakage across the air heater causes the CEM reading to be 3 - 4 points higher than the furnace and was determined by comparing the monitor and furnace O_2 meter readings.
- CEM Data Reduction: The CEM is certified to strip-charts only which are manually read. It is estimated that this procedure introduces a ± 5 percent error in O_2 and NO.
- Monitor Relative Accuracy: The monitor certification showed that the NO relative accuracy was 12.4 percent. Relative accuracy tests are not regularly scheduled.
- Calibration Procedure: Monitor calibration is by means of a reference cell which is positioned in the optical path every eight hours. This cell, however, disconnects a temperature compensation circuit. Recently, the utility has performed some tests wherein NBS traceable gases (at 50 percent and 90 percent full-scale) have been introduced directly into the monitor. These tests have shown that the use of the monitor reference cell results in a higher reading, typically on the order of 20 percent. The utility now plans to automatically perform NO monitor calibration on a daily basis with the NBS traceable gases.
- Quality Assurance Procedure: At present, the utility has a written continuous emission monitoring quality assurance program (preliminary document supplied to KVB). This program involves a system of procedures for detecting daily operating problems and providing immediate solutions. The program also includes a system for insuring proper application of daily operating procedures and adequate communications between operating personnel and management at each level. However, the formal quality assurance program was not in effect during the May - July 1979 time period.

6.2.4 Coal Supply

- The coal supply for Unit 3 is a blend of physically cleaned coal and run-of-mine coals. The physical coal cleaning (PCC) facility at Homer City is designed to separate pyritic sulfur from a base coal with a 3-3.5 percent sulfur content. At present, Unit 3 is operating under an innovative technology waiver with respect to the 1971 SO_2 NSPS, and if the waiver is not renewed then a flue gas desulfurization system may have to be fitted. (Units 1 and 2 are subject only to the State of Pennsylvania SO_2 limitations and can burn a coal with a higher sulfur content.)

SECTION 7.0

LOUISVILLE GAS AND ELECTRIC - MILL CREEK STATION, UNIT 3

7.1 EMISSIONS ANALYSIS

KVB, under subcontract to Exxon, accumulated 64 days of gaseous emission monitoring on this unit during two periods: January 19 - February 20, 1981 and March 24 - April 23, 1981.

Table 7-1 summarizes the computer analysis and indicates that valid data was obtained during 79.8 percent of total 64-day monitoring period. If the boiler down-time is considered then the monitor reliability is 86.5 percent.

Figure 7-1 is a plot of NO and O_2 versus boiler load and exhibits a relatively flat NO characteristic over the corresponding load range. Fairly close agreement is noted with the 1971 NSPS performance test NO_x. (The monitor is measuring NO only but the performance test is in terms of total NO_x.) The NO distribution shown in Figure 7-2, is represented in normal probability coordinates with a mean of 215 ng/J and standard deviation of 27 ng/J. The unit load (Figure 7-3) is represented by a median value of 270 MWe gross, which is 63.5 percent of rating.

The analysis of the emissions data with respect to the 1978 NSPS indicates that:

1. The first 30-day rolling average would have met the 1978 NSPS performance test requirement.
2. There would have been no periods of excess emissions on a 30-day rolling average basis.

The coal used by this boiler is classified as a low volatile bituminous. Ultimate analyses were performed on samples obtained during the first monitoring period with the results presented in Table 7-2. These data do not permit an analysis to be performed to assess the relative constancy of the coal properties.

(text continued on page 7-12)

TABLE 7-1. COMPUTER ANALYSIS SUMMARY - MILL CREEK UNIT 3

```
                          **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
LOUISVILLE GAS AND ELEC.  MILL CREEK UNIT 3
B+W BOILER DUAL REGISTER BURNERS
425 MWE GROSS  LOW VOLATILE BITUMINOUS
PERFORMANCE NOX = 0.623 LB/10**6BTU, 268NG/J
NO  MONITOR REL. ACC. = 17.8PC. 11.52 PC
DAY 1 = 1/19/81, DAY 38 = 3/24/81
```

(continued)

TABLE 7-1. (CONTINUED)

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DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
1	.524	225.	.0615	26.4	7.6	2.67	199.	3.1
4	.488	210.	.0698	30.0	6.9	.64	325.	59.9
5	.441	190.	.0503	21.6	5.3	1.88	300.	66.1
6	.393	169.	.0466	20.0	6.0	.82	225.	30.9
7	.361	155.	.0229	9.8	8.6	.44	183.	12.6
8	.421	181.	.0477	20.5	9.7	1.87	161.	60.6
9	.451	194.	.0050	2.2	11.7	.21	100.	3.2
10	.475	204.	.0116	5.0	11.8	.19	103.	2.8
11	.470	202.	.0072	3.1	11.0	.31	103.	1.8
12	.460	198.	.0234	10.1	11.0	.18	99.	1.0
15	.530	228.	.0378	16.2	6.7	3.21	309.	139.1
16	.579	249.	.0266	11.4	5.0	.33	377.	26.9
17	.533	229.	.0472	20.3	5.7	1.90	381.	72.1
18	.539	232.	.0418	18.0	4.5	.47	397.	10.4
22	.491	211.	.0274	11.8	5.6	2.17	284.	90.7
23	.465	200.	.0264	11.4	5.0	.97	295.	69.0
24	.531	228.	.0347	14.9	4.9	1.19	348.	76.4
25	.541	232.	.0144	6.2	4.3	.51	384.	20.4
26	.498	214.	.0572	24.6	5.5	.30	319.	55.9
27	.494	212.	.0504	21.6	7.1	1.24	252.	81.4
28	.493	212.	.0210	9.0	8.1	1.83	200.	43.0
29	.508	218.	.0368	15.8	7.3	2.26	264.	85.3
30	.475	204.	.0260	11.2	6.2	1.82	265.	78.5
31	.469	202.	.0296	12.7	7.1	1.43	238.	60.2
33	.494	212.	.0639	27.5	6.6	1.02	295.	101.5
34	.480	206.	.0184	7.9	5.3	.51	292.	30.2
35	.488	210.	.0435	18.7	5.9	.80	292.	61.3
36	.536	230.	.0532	22.9	6.2	1.49	287.	84.5
37	.497	213.	.0904	38.8	8.2	1.85	198.	48.7
40	.507	218.	.0587	25.2	6.0	2.36	300.	95.0
41	.512	220.	.0354	15.2	5.3	1.75	318.	95.9
42	.505	217.	.0645	27.7	5.4	1.32	319.	84.0
43	.517	222.	.0393	16.9	5.9	1.85	311.	85.8
44	.475	204.	.0351	15.1	8.8	1.95	199.	65.3
45	.438	188.	.0114	4.9	11.7	.29	100.	2.1
46	.448	192.	.0086	3.7	12.0	.11	100.	1.2
47	.506	217.	.0507	21.8	7.7	2.73	251.	93.9
48	.485	209.	.0423	18.2	6.1	1.19	257.	43.0
49	.482	207.	.0180	7.7	6.3	1.68	256.	51.0
50	.540	232.	.0515	22.1	6.0	1.06	316.	79.2
51	.508	218.	.0552	23.7	5.2	.27	318.	60.1
52	.482	207.	.0263	11.3	5.2	1.13	309.	68.3
53	.478	206.	.0266	11.4	6.1	.52	248.	11.2
54	.484	208.	.0471	20.2	6.4	1.48	261.	88.8
55	.559	240.	.0549	23.6	5.1	.11	351.	48.6
56	.570	245.	.0428	18.4	5.6	.77	340.	60.0
57	.544	234.	.0372	16.0	4.9	.60	334.	73.6
58	.533	229.	.0240	10.3	5.0	.74	353.	58.4
59	.539	232.	.0716	30.7	7.4	1.99	246.	113.0
60	.530	228.	.0362	15.5	5.7	.85	295.	35.0
61	.512	220.	.0983	42.2	6.1	2.33	344.	96.1
62	.561	241.	.0265	11.4	5.4	1.47	354.	62.4
63	.549	236.	.0273	11.7	4.8	1.26	356.	63.5
64	.548	235.	.0338	14.5	5.0	1.16	350.	68.9

(continued)

TABLE 7-1. (CONTINUED)

NO. AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	103.	85.	120.
2	137.	120.	154.
3	171.	154.	188.
4	205.	188.	222.
5	239.	222.	256.
6	273.	256.	290.
7	307.	290.	324.
8	341.	324.	358.
9	375.	358.	392.
10	409.	392.	426.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD PROB. PERCENT
1	164	.458	197.	.0236	10.1	11.44	.82	13.38
2	25	.444	191.	.0493	21.2	9.90	.87	15.42
3	90	.435	187.	.0551	23.7	8.84	.98	22.76
4	143	.472	203.	.0578	24.8	7.57	1.37	34.42
5	114	.493	212.	.0522	22.4	6.00	.85	43.72
6	160	.471	202.	.0457	19.6	5.63	.77	56.77
7	69	.503	216.	.0302	13.0	5.29	.57	62.40
8	73	.520	224.	.0462	19.8	5.17	1.17	68.35
9	189	.549	236.	.0409	17.6	4.80	.79	83.77
10	198	.557	239.	.0388	16.5	4.59	.73	99.92

(continued)

TABLE 7-1. (CONTINUED)

NO PROBABILITY

NO CELL DIMENSIONS

CELL NUMBER	CENTER LB/10**6 BTU	CENTER NG/J	LOWER BOUNDARY LB/10**6 BTU	LOWER BOUNDARY NG/J	UPPER BOUNDARY LB/10**6 BTU	UPPER BOUNDARY NG/J
1	.321	138.	.301	129.	.342	147.
2	.362	155.	.342	147.	.382	164.
3	.402	173.	.382	164.	.423	182.
4	.443	190.	.423	182.	.463	199.
5	.484	208.	.463	199.	.504	217.
6	.524	225.	.504	217.	.545	234.
7	.565	243.	.545	234.	.585	251.
8	.605	260.	.585	251.	.626	269.
9	.646	278.	.626	269.	.666	286.
10	.687	295.	.666	286.	.707	304.

NO PROBABILITY RESULTS

CELL NUMBER	NUMBER OF ENTRIES	CUM. PROB. PERCENT LESS THAN
1	15	1.22
2	33	3.92
3	53	8.24
4	226	26.67
5	370	56.85
6	220	74.80
7	218	92.58
8	77	98.86
9	11	99.76
10	2	99.92

(continued)

TABLE 7-1. (CONTINUED)

```
                         **NOX COMPLIANCE WITH RESPECT TO 1971 NSPS**
            FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
               FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
     FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)
            FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)
                         THIS BOILER WAS OPERATED WITH BITUMINOUS COAL
            THE NOX MEASURED DURING THE PERFORMANCE TEST WAS   .623  LB/10**6 BTU (268. NG/J)
AN ANALYSIS OF 3-HOUR NO  ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
               INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     0  OCCASIONS
AN ANALYSIS OF 3-HOUR NO  BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
               INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     0  OCCASIONS
```

(continued)

TABLE 7-1. (CONTINUED)

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                **NOX COMPLIANCE WITH RESPECT TO 1978 NSPS**

                    1978 NSPS NOX EMISSION LIMITATIONS
              SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
               BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
    LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
               OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)


   ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED     0  EXCEEDANCES

                        30-DAY ROLLING AVERAGES
        EMISSION LIMITATION  .60 LB/10**6 BTU  258. NG/J

             SEQUENTIAL              30-DAY AVERAGE NO
              AVERAGE               LB/10**6 BTU  NG/J
             ----------             ------------  ----
                 1                      .488      210.
                 2                      .487      209.
                 3                      .488      210.
                 4                      .491      211.
                 5                      .494      212.
                 6                      .496      213.
                 7                      .497      214.
                 8                      .499      214.
                 9                      .499      214.
                10                      .499      215.
                11                      .502      216.
                12                      .501      215.
                13                      .498      214.
                14                      .496      213.
                15                      .494      212.
                16                      .497      213.
                17                      .500      215.
                18                      .500      215.
                19                      .500      215.
                20                      .502      215.
                21                      .503      216.
                22                      .503      216.
                23                      .505      217.
                24                      .508      218.
                25                      .510      219.
```

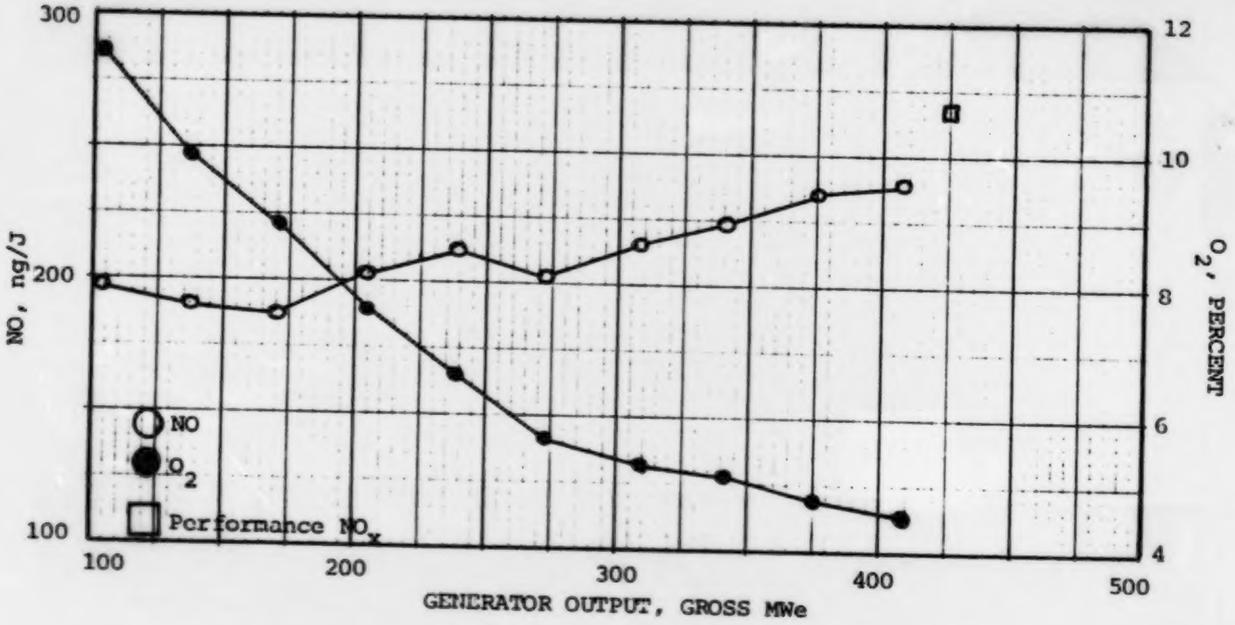

Figure 7-1. Mill Creek Unit 3 - Boiler Characteristics

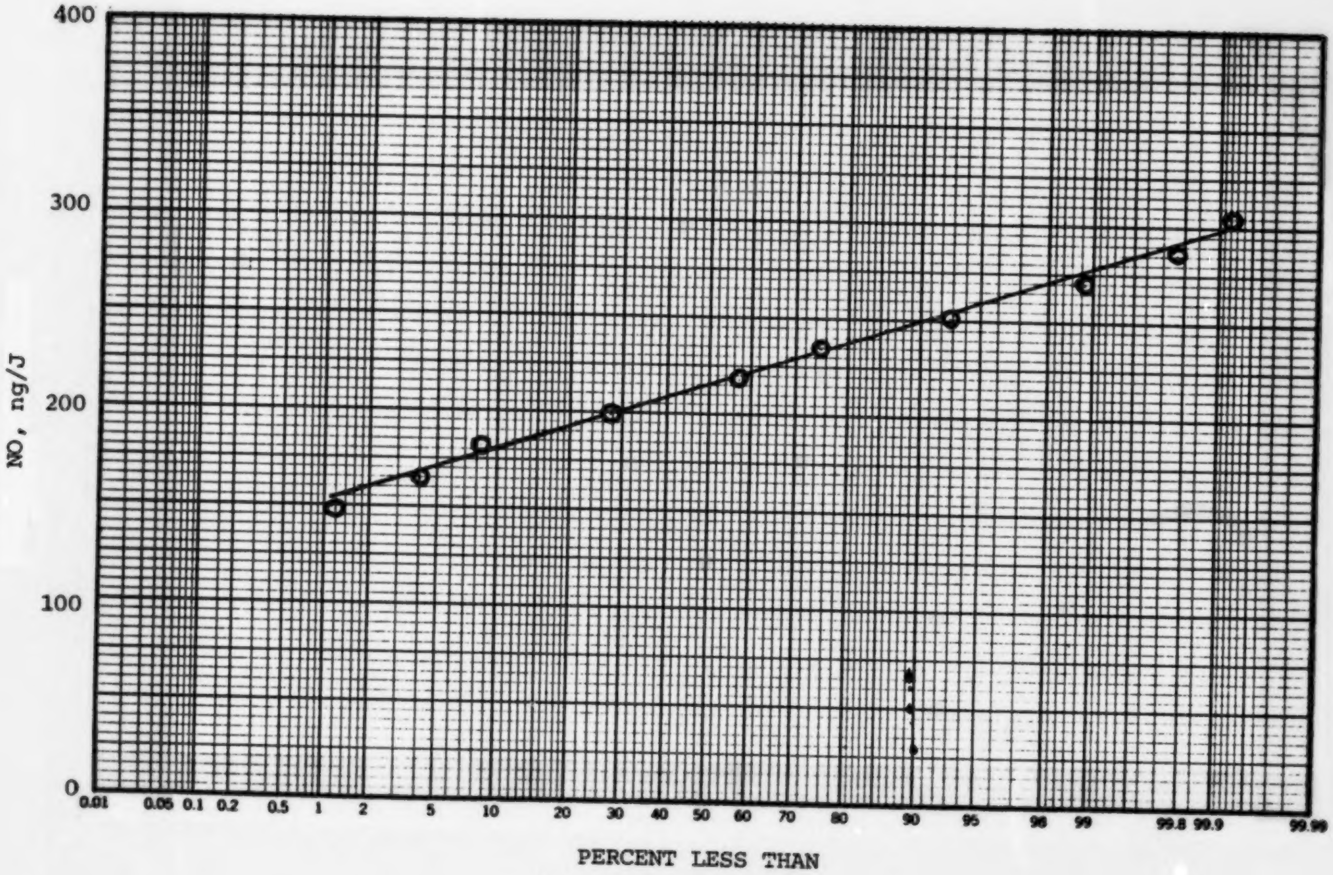

Figure 7-2. Mill Creek Unit 3 - NO Probability

7-3

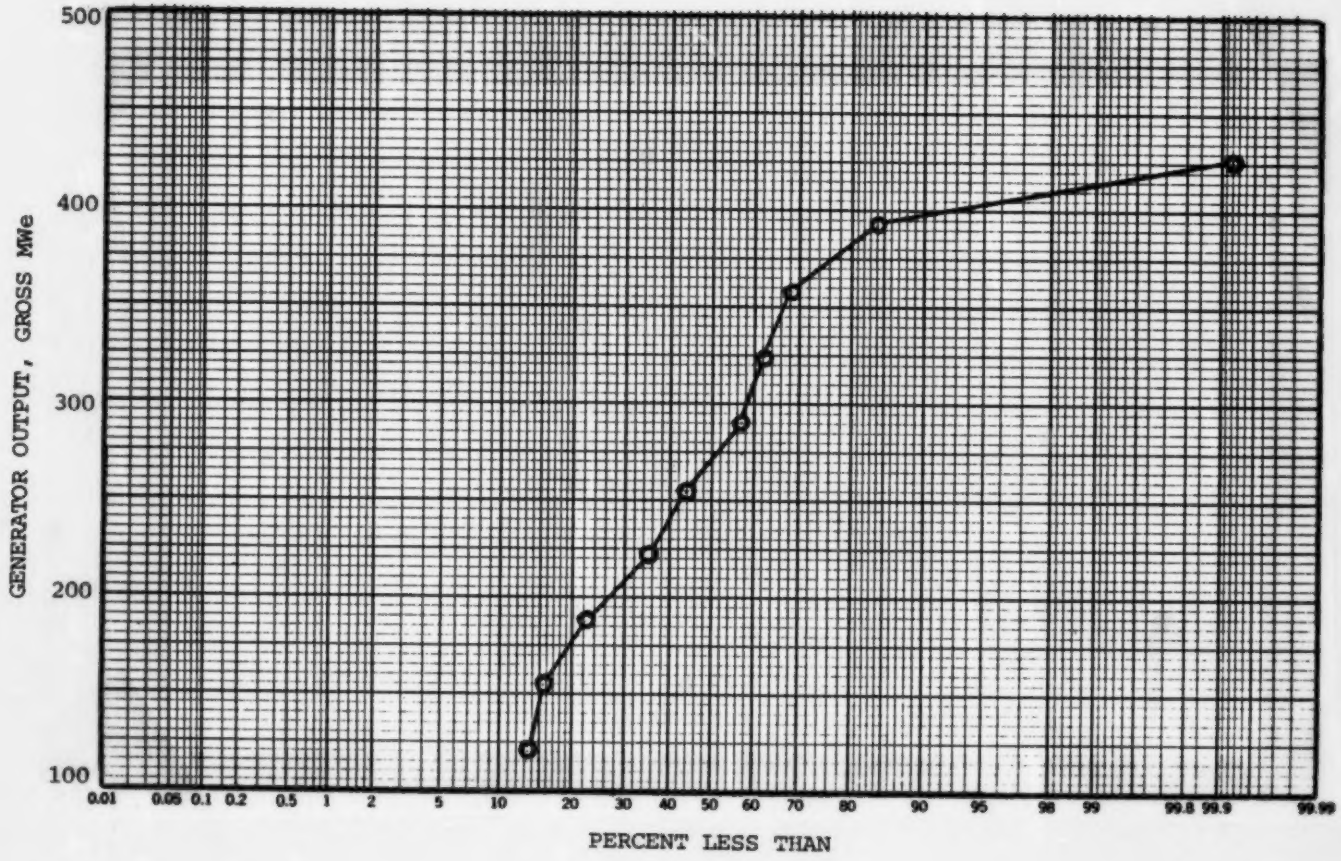

Figure 7-3. Mill Creek Unit 3 - Load Probability

7-4

TABLE 7-2. AS-RECEIVED COAL ANALYSES --
MILL CREEK UNIT 3

Weight Percent	Sample Date 1-18-81	 2-20-81
Moisture	8.43	9.43
Carbon	65.83	64.22
Hydrogen	4.65	4.47
Nitrogen	1.14	1.29
Chlorine	0.05	0.05
Sulfur	4.04	3.74
Ash	9.63	10.42
Oxygen (by diff.)	6.23	6.38
Btu/lb	11,963	11,703
kJ/kg	27,825	27,221

13

The extractive continuous emissions monitoring system drew a gaseous sample from the duct between the economizer and air heater. The CEM included the following analytical instruments:

Emission Species	Manufacturer	Measurement Method	Model No.
Nitrogen Oxides	Thermo Electron	Chemiluminescent	10BR
Oxygen	Beckman Instrument	Polarographic	742
Carbon Dioxide	Horiba Instrument	NDIR	PIR-2000
Carbon Monoxide	Horiba Instrument	NDIR	PIR-2000

The nitrogen oxides instrument was configured to measure NO only and not total NO_x ($NO + NO_2$).

CEM certification was performed twice - once during each monitoring period. The results obtained for the NO and O_2 analyzers are compared with the EPA specifications in Tables 7-3 and 7-4.

The data reduction computer program hourly-averaged input is contained in Appendix J.

7.2 UNIT CHARACTERISTICS

No site visit was made, however, unit characteristics were obtained by personal communication with Mr. G. C. Ecken, Jr., Station Supervisor.

7.2.1 Boiler Design

- Boiler manufacturer is Babcock and Wilcox.
- Opposed face fired.
- 40 dual register burners. Eight rows of 5 burners each.
- Furnace heat release rate is 12,927 Btu/hr-ft^3.

(text continued on page 7-15)

TABLE 7-3. NO ANALYZER CERTIFICATION RESULTS--
MILL CREEK UNIT 3

Parameter	EPA Specification	January 1981	March 1981
Relative Accuracy	$\leq$20%	17.8%	11.52%
Calibration Error	$\leq$5%	1.19% (mid range) 0.71% (high-range)	0.7% 1.26%
Zero Drift (2 hour)	$\leq$2% of span	0.034%	0.04%
Zero Drift (24-hour)	$\leq$2% of span	0.150%	0.145%
Calibration Drift (2-hr)	$\leq$2% of span	0.085%	0.155%
Calibration Drift (24-hr)	$\leq$2.5% of span	0.280%	0.46%
Response Time	15 minute max	3.53 min.	0.92 min.
Operational Period	168 hour minimum	168 hour	168 hour

TABLE 7-4. O_2 ANALYZER CERTIFICATION RESULTS--MILL CREEK UNIT 3

Parameter	EPA Specification	January 1981	March 1981
Zero Drift (2-hour)	$\leq$0.4% O_2	DNA*	DNA
Zero Drift (24-hour)	$\leq$0.5% O_2	DNA	DNA
Calibration Drift (2-hour)	$\leq$0.4% O_2	0.03% O_2	0.03% O_2
Calibration Drift (24-hour)	$\leq$0.5% O_2	0.075% O_2	0.25% O_2
Response Time	10 minute max	2.1 min.	0.82 min.
Operational Period	168 hour minimum	168 hour	168 hour

*Does not apply; instrument has no zero adjustment.

- Generator output is 425 MWe gross.
- Coal is a high sulfur, low volatile bituminous.
- Air supply contains an O_2 trim.
- The boiler is equipped with a flue gas recirculation system, however, it has never been used.

7.2.2 Operational Items

- With four mills in service, the design O_2 is 4.0 percent at rated steam flow and increases to 6.4 percent O_2 at 33 percent rated steam flow.
- Operating heat rate is quoted as 9970 Btu/kWh.
- Steam temperature SH/RH: 1005°F/1005°F.
- The boiler has not experienced any unusual slagging, fouling, corrosion or tube wastage due to the use of high sulfur coal.
- Flyash carbon content has been measured at 1.1 percent by weight.
- The unit has not experienced any load limitations.

7.2.3 Flue Gas Desulfurization and Particulate Control

- Wet scrubber for SO_2.
- Electrostatic precipitator.

7.2.4 Coal Source

Several mines in Western Kentucky.

SECTION 8.0

PROPRIETARY INFORMATION - UNITS A AND B

8.1 EMISSIONS ANALYSIS

Ninety days of monitoring data, covering January - March 1981, were analyzed for both units. Excluding time periods when the boiler was off-line or no data supplied resulted in monitor reliabilities (monitor/boiler operating hours) of 89.6 and 87.3 percent for Units A and B, respectively.

The units were described by the utility as being nominally identical, however, the computer analyses did identify differences in NO emission characteristics. Tables 8-1 and 8-2 are the computer data reduction analyses for Units A and B, respectively. Figures 8-1 through 8-3 are the results for Units A with the NO_x characteristics (Figure 8-1) at high load slightly exceeding the 1971 NSPS performance value. The load probability (Figure 8-2) is representable only in terms of its median value -- 212 gross MWe (60.6 percent of rating). The median NO (Figure 8-3) is 192 ng/J.

The 30-day rolling average analysis for Unit A indicated:

1. It would have complied with the 1978 NSPS performance test requirement.

2. There would have been no periods of excess NO_x emissions with respect to the 1978 NSPS.

The latter statement must be qualified since the monitor is measuring NO only and not NO_x ($NO + NO_2$). If NO_2 represents 3 percent of total NO_x then the 30-day rolling analysis would have shown one or two periods of excess emissions. The maximum margin with respect to the 1978 NSPS would have been 25 ng/J (0.06 $lb/10^6$ Btu). It is of interest that this unit was determined to have exceeded the 1971 standard on 75 occasions (3-hour rolling average) and 31 ocassions (3-hour block average). The potential periods of excess emissions were 1765 (rolling average) and 589 (block average).

Unit B's boiler characteristics (Figure 8-4) are not completely defined below a load of 133 gross MWe. The high load NO appears to slightly

(text continued on page 8-18)

TABLE 8-1. COMPUTER ANALYSIS SUMMARY - UNIT A

```
                         **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
CONFIDENTIAL INFORMATION      UNIT A
COMBUSTION ENGR BOILER WITH OVERFIRE AIR  350 MWE GROSS
SUBBITUMINOUS (C) COAL
NO  MONITOR RELATIVE ACCURACY = 8.0 PC
DAY 1 = 1 JANUARY 1981
PERFORMANCE NOX = 0.61 LB/10**6BTU (262 NG/J)
```

(continued)

TABLE 8-1. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
1	.505	217.	.0687	29.5	8.0	.50	250.	37.6
2	.492	211.	.0952	40.9	8.1	1.13	250.	66.4
3	.436	187.	.1260	54.1	8.5	1.09	226.	63.9
4	.480	206.	.0672	20.9	8.1	.77	235.	60.2
5	.544	234.	.1072	46.1	7.7	.86	267.	50.1
8	.345	148.	.1204	51.7	8.1	1.08	240.	62.2
9	.400	170.	.1187	51.0	8.3	.90	230.	60.3
10	.434	186.	.0842	36.2	8.1	.90	242.	46.2
11	.428	184.	.0777	33.4	8.4	.89	235.	54.3
12	.470	202.	.0903	38.8	8.3	.90	245.	65.0
13	.416	179.	.0791	34.0	9.0	1.23	218.	55.6
14	.351	151.	.0420	18.0	8.2	2.20	211.	39.3
15	.455	196.	.0728	31.0	8.6	1.14	201.	63.4
16	.392	168.	.1525	65.5	8.4	.88	243.	64.2
17	.465	200.	.0935	40.2	8.0	.93	231.	57.7
18	.397	170.	.0518	22.3	9.5	.93	198.	61.4
19	.365	157.	.0411	17.7	8.7	1.08	219.	53.9
20	.377	162.	.0543	23.3	9.5	1.23	190.	52.7
21	.465	200.	.1364	58.6	8.6	.89	200.	67.6
22	.395	170.	.0733	31.5	8.4	.71	210.	42.6
25	.302	130.	.0676	29.1	9.0	.76	203.	45.1
26	.315	135.	.0527	22.6	9.2	.73	199.	66.9
27	.340	146.	.0338	14.5	9.4	1.03	194.	50.4
28	.420	180.	.0819	35.2	9.4	1.40	198.	59.2
29	.547	235.	.1376	59.1	9.0	1.16	204.	59.8
30	.737	317.	.1435	61.6	8.3	.85	251.	64.2
31	.538	231.	.0649	27.9	8.8	.34	208.	23.9
32	.403	173.	.0296	12.7	9.3	.33	170.	13.9
33	.449	193.	.0596	25.6	9.1	.59	203.	20.2
34	.544	234.	.1364	58.6	9.6	.66	223.	27.8
35	.693	298.	.0845	36.3	10.3	1.10	202.	30.8
36	.640	275.	.0830	35.7	10.2	1.05	214.	37.1
37	.522	224.	.1381	59.3	10.5	1.40	187.	41.7
38	.398	171.	.0320	13.7	10.9	.14	187.	7.2
43	.658	283.	.1198	51.5	8.7	.67	252.	52.1
45	.512	220.	.0254	10.9	9.8	.34	181.	13.6
46	.515	221.	.0392	16.8	10.6	.53	173.	25.4
47	.457	196.	.0416	17.9	9.9	.63	167.	21.6
48	.378	163.	.0723	31.0	10.0	.24	153.	6.8
49	.438	188.	.0674	28.9	9.2	.78	193.	34.7
50	.442	190.	.0787	33.8	9.2	.74	193.	34.1
51	.436	187.	.0567	24.4	9.1	.70	185.	37.0
52	.424	182.	.0674	28.9	9.5	.56	170.	27.4
53	.332	143.	.0129	5.6	10.1	.22	151.	4.4
54	.408	175.	.0657	28.2	9.2	.89	184.	27.0
55	.336	144.	.0581	24.9	9.2	.79	170.	40.6
56	.536	230.	.1326	57.0	7.8	1.08	249.	64.5
57	.356	153.	.1070	46.0	9.0	.97	191.	56.1
58	.548	240.	.2065	88.7	8.0	1.07	268.	70.5
59	.552	237.	.1261	54.2	7.7	.83	260.	61.8
60	.416	179.	.0637	27.3	8.3	.59	221.	39.7
61	.508	218.	.2101	90.2	7.9	.88	259.	70.5
62	.523	225.	.1846	79.3	8.0	1.22	260.	75.0
63	.471	202.	.1922	82.6	8.1	.89	224.	53.0
64	.330	142.	.0657	28.2	8.8	1.09	213.	47.6
65	.440	189.	.1016	43.6	8.1	.82	248.	54.1
66	.320	137.	.0520	22.7	9.3	.68	191.	27.6
67	.354	152.	.0289	12.4	9.4	.46	184.	21.8
68	.476	204.	.0873	37.5	8.1	1.12	254.	58.2
69	.601	258.	.1318	56.6	7.6	.80	290.	64.6
70	.577	248.	.1586	68.1	7.6	.80	203.	57.0
71	.447	192.	.1535	66.0	8.1	.89	241.	64.3
72	.497	214.	.0749	32.2	7.9	.65	257.	44.4
73	.443	190.	.0906	38.8	8.1	.80	240.	33.6
74	.372	160.	.0425	18.3	9.0	.54	180.	21.8
75	.498	214.	.1056	45.3	8.1	1.03	290.	70.3
76	.472	203.	.0591	25.4	8.0	.52	254.	37.8
77	.506	217.	.0975	41.9	8.2	1.21	294.	69.6
78	.523	225.	.1244	53.4	7.4	.73	277.	50.4
81	.419	180.	.0758	32.6	9.1	.61	183.	43.0
84	.530	228.	.1013	43.5	8.3	1.64	270.	82.6
87	.517	222.	.1416	60.6	8.5	.62	245.	53.2
88	.461	198.	.0755	32.4	9.2	.63	207.	39.1
89	.500	215.	.1188	51.0	7.9	.83	271.	67.2
90	.570	245.	.1581	68.3	7.6	.57	290.	67.8

TABLE 8-1. (CONTINUED)

NO AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	50.	33.	66.
2	83.	66.	99.
3	116.	99.	133.
4	149.	133.	166.
5	182.	166.	199.
6	216.	199.	232.
7	249.	232.	265.
8	282.	265.	299.
9	315.	299.	332.
10	348.	332.	365.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD PROB. PERCENT
1	2	.305	131.	.0212	9.1	11.40	3.68	.11
2	2	.375	161.	.0636	27.3	11.75	2.19	.23
3	15	.405	174.	.0548	23.5	11.12	.11	1.07
4	417	.350	150.	.0842	36.2	10.05	.62	24.66
5	297	.401	172.	.0885	38.0	9.34	.57	41.46
6	297	.441	189.	.1012	43.5	8.75	.63	58.26
7	231	.480	206.	.1087	46.7	8.19	.74	71.32
8	244	.562	241.	.0939	40.3	7.62	.33	85.12
9	245	.620	266.	.0926	39.8	7.31	.28	98.98
10	17	.679	292.	.0892	38.3	7.21	.35	99.94

(continued)

TABLE 8-1. (CONTINUED)

NO PROBABILITY

NO CELL DIMENSIONS

CELL NUMBER	CENTER LB/10**6 BTU	CENTER NG/J	LOWER BOUNDARY LB/10**6 BTU	LOWER BOUNDARY NG/J	UPPER BOUNDARY LB/10**6 BTU	UPPER BOUNDARY NG/J
1	.221	95.	.185	79.	.257	110.
2	.293	126.	.257	110.	.329	141.
3	.365	157.	.329	141.	.401	172.
4	.437	188.	.401	172.	.473	203.
5	.509	219.	.473	203.	.545	234.
6	.581	250.	.545	234.	.617	265.
7	.653	281.	.617	265.	.689	296.
8	.725	311.	.689	296.	.761	327.
9	.797	342.	.761	327.	.833	358.
10	.869	373.	.833	358.	.905	389.

NO PROBABILITY RESULTS

CELL NUMBER	NUMBER OF ENTRIES	CUM. PROB. PERCENT LESS THAN
1	55	3.11
2	214	15.21
3	444	40.33
4	282	56.28
5	294	72.91
6	233	86.09
7	130	93.44
8	83	98.13
9	20	99.26
10	12	99.94

(continued)

TABLE 8-1. (CONTINUED)

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                    **NOX COMPLIANCE WITH RESPECT TO 1971 NSPS**
      FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
        FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)
      FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)
                    THIS BOILER WAS OPERATED WITH SUBBITUMINOUS COAL
          THE NOX MEASURED DURING THE PERFORMANCE TEST WAS   .610  LB/10**6 BTU (262. NG/J)
AN ANALYSIS OF 3-HOUR NO  ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
            INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON    75  OCCASIONS
AN ANALYSIS OF 3-HOUR NO  BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
            INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON    31  OCCASIONS
```

(continued)

TABLE 8-1. (CONTINUED)

NOX COMPLIANCE WITH RESPECT TO 1979 NSPS

1979 NSPS NOX EMISSION LIMITATIONS
SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)

ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED 0 EXCEEDANCES

30-DAY ROLLING AVERAGES
EMISSION LIMITATION .50 LB/10**6 BTU 215. NG/J

SEQUENTIAL AVERAGE	30-DAY AVERAGE NO LB/10**6 BTU	NG/J
1	.441	189.
2	.447	192.
3	.452	194.
4	.455	195.
5	.452	194.
6	.456	196.
7	.461	198.
8	.465	200.
9	.465	200.
10	.464	199.
11	.463	199.
12	.464	199.
13	.466	200.
14	.465	200.
15	.463	199.
16	.462	198.
17	.460	197.
18	.465	200.
19	.465	200.
20	.468	201.
21	.474	203.
22	.477	205.
23	.484	208.
24	.488	210.
25	.492	211.
26	.484	208.
27	.476	204.
28	.467	201.
29	.466	200.
30	.466	200.
31	.468	201.
32	.464	200.
33	.458	197.
34	.458	197.
35	.459	197.
36	.449	193.
37	.449	193.
38	.448	192.
39	.449	193.
40	.454	195.
41	.453	195.
42	.456	196.
43	.459	197.
44	.460	197.
45	.465	200.
46	.471	202.

TABLE 8-2. COMPUTER ANALYSIS SUMMARY - UNIT B

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                         **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
CONFIDENTIAL INFORMATION     UNIT B

COMBUSTION ENGR BOILER WITH OVERFIRE AIR  350 MWE GROSS

SUBBITUMINOUS (C) COAL

NO. MON. REL. ACCURACY = 6.5 PC

DAY 1 = 1 JANUARY 1981

PERFORMANCE NOX = 0.49 LB/10**6BTU (211 NG/J)
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(continued)

TABLE 8-2. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
1	.248	107.	.0344	14.8	5.8	.52	231.	44.9
2	.281	121.	.0307	13.2	5.7	.50	256.	51.6
4	.293	126.	.0168	7.2	5.8	.36	240.	32.2
5	.262	113.	.0277	11.9	5.5	.36	209.	41.9
6	.242	104.	.0170	7.3	5.8	.62	262.	41.2
7	.300	129.	.0465	20.0	5.2	.36	301.	34.0
8	.247	106.	.0264	11.3	6.0	.49	246.	40.1
9	.267	115.	.0397	17.1	5.9	.54	260.	63.0
10	.257	110.	.0250	10.7	5.9	.64	272.	76.2
11	.282	121.	.0308	13.2	5.8	.24	280.	30.4
12	.297	128.	.0461	19.8	5.8	.95	254.	60.4
13	.409	176.	.0525	22.6	6.1	.35	273.	71.4
14	.348	149.	.1196	51.4	6.2	.40	264.	93.5
15	.430	185.	.0420	18.0	6.4	.38	270.	49.9
16	.413	177.	.0301	12.9	6.8	.77	250.	67.4
17	.391	168.	.0406	17.5	6.8	.40	240.	43.1
18	.328	141.	.0313	13.5	7.1	.54	207.	35.0
19	.436	187.	.0506	21.7	6.2	.42	291.	41.8
20	.404	174.	.0557	23.9	6.3	.63	274.	61.3
21	.386	166.	.0514	22.1	6.7	.66	229.	60.6
22	.396	170.	.0599	25.7	6.1	.56	279.	54.1
23	.423	182.	.0375	16.1	6.2	.70	279.	71.9
24	.445	191.	.0632	27.1	6.0	.25	294.	33.0
25	.374	161.	.0309	13.3	6.7	.75	230.	60.6
26	.435	187.	.0476	20.5	6.1	.99	295.	80.9
27	.468	201.	.0463	19.9	5.8	.22	344.	.2
28	.552	237.	.0376	16.2	5.4	.43	344.	.4
29	.530	228.	.0509	21.9	4.8	.18	300.	.3
30	.532	229.	.0795	34.2	5.6	.44	321.	36.2
31	.357	154.	.0353	15.2	6.4	.73	234.	59.7
34	.400	172.	.0285	12.2	6.6	.74	239.	55.6
35	.385	166.	.0675	29.0	7.3	.49	188.	20.1
37	.317	136.	.0181	7.8	6.5	.81	220.	61.9
38	.304	131.	.0275	11.8	6.9	.54	189.	45.0
39	.311	134.	.0348	15.0	7.3	.22	165.	21.5
40	.301	129.	.0239	10.3	6.5	.63	215.	53.7
41	.323	139.	.0309	13.3	6.4	.73	221.	53.8
42	.358	154.	.0613	26.4	5.8	.23	201.	31.5
43	.328	141.	.0228	9.8	6.4	.42	228.	39.0
44	.349	150.	.0213	9.2	7.0	.41	183.	24.0
45	.331	142.	.0545	23.4	7.0	.57	182.	39.0
46	.279	120.	.0344	14.8	7.4	.16	155.	0.2
47	.311	134.	.0316	13.6	6.8	.66	190.	37.2
52	.438	188.	.0666	28.6	7.1	.41	188.	28.7
53	.443	190.	.0469	20.1	7.1	.31	179.	18.0
54	.412	177.	.0501	21.5	6.5	.51	208.	30.3
55	.430	185.	.0380	16.3	6.5	.49	204.	33.5
56	.407	175.	.0331	14.2	6.8	.22	187.	11.1
57	.370	159.	.0953	41.0	6.3	.82	229.	66.5
58	.409	176.	.0566	24.3	5.8	.52	288.	57.0
59	.407	175.	.1337	57.4	6.5	.76	250.	77.6
60	.335	144.	.0737	31.6	6.2	.54	240.	45.9
61	.347	149.	.0578	24.8	6.3	.82	246.	70.1
62	.315	135.	.0320	13.8	5.8	.57	269.	49.7
63	.364	156.	.0764	32.8	6.0	.63	251.	49.7
64	.384	165.	.0634	27.2	6.3	.63	233.	50.3
65	.437	188.	.0801	34.4	6.2	.62	242.	49.5
66	.421	181.	.0680	29.2	6.3	.75	230.	60.5
67	.415	178.	.0360	15.4	6.5	.86	233.	66.5
68	.391	168.	.0749	32.2	6.1	.92	235.	72.1
69	.362	155.	.0696	29.9	6.4	.66	219.	55.4
71	.350	150.	.0479	20.6	6.1	.57	239.	43.3
73	.340	146.	.0437	18.8	5.7	.74	269.	52.6
74	.287	124.	.0269	11.6	6.1	.80	221.	45.0
75	.404	174.	.1242	53.4	5.8	1.17	260.	40.3
76	.411	177.	.0420	18.1	5.5	.73	255.	51.0
77	.467	200.	.1028	44.2	5.8	.63	277.	56.0
78	.575	247.	.1126	48.4	5.8	.51	291.	46.3
80	.582	250.	.0869	37.3	6.3	.57	280.	61.5
81	.516	222.	.1181	50.7	6.0	.25	289.	51.0
82	.480	206.	.1103	47.4	6.3	.72	283.	74.0
83	.572	246.	.0462	19.8	5.9	.07	315.	34.0
84	.602	259.	.0537	23.1	5.5	.61	264.	96.2
86	.464	199.	.0459	19.7	5.5	.32	315.	35.0
87	.492	212.	.0840	36.1	5.7	.31	305.	30.0
88	.427	184.	.0411	17.7	6.3	.52	284.	50.0
89	.511	219.	.1017	43.7	6.1	.40	300.	40.3
90	.618	266.	.0533	22.9	5.6	.45	340.	4.0

TABLE 8-2. (CONTINUED)

NO AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	75.	60.	89.
2	104.	89.	118.
3	133.	118.	147.
4	162.	147.	176.
5	191.	176.	205.
6	220.	205.	235.
7	249.	235.	264.
8	278.	264.	293.
9	307.	293.	322.
10	336.	322.	351.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD PROB. PERCENT
1	2	.535	230.	.1344	57.7	5.60	.28	.11
2	1	.510	219.	.0000	.0	6.30	.00	.16
3	34	.330	142.	.1159	49.8	7.23	.58	2.01
4	303	.329	141.	.0697	29.9	7.34	.41	18.43
5	223	.348	149.	.0738	31.7	6.79	.36	30.51
6	187	.351	151.	.0704	30.2	6.43	.34	40.65
7	195	.350	150.	.0691	29.7	6.02	.36	51.22
8	167	.373	160.	.0798	34.3	5.74	.35	60.27
9	346	.399	171.	.0935	40.2	5.62	.38	79.02
10	386	.512	220.	.0964	41.4	5.57	.37	99.95

(continued)

TABLE 8-2. (CONTINUED)

NO PROBABILITY

NO CELL DIMENSIONS

CELL NUMBER	CENTER LB/10**6 BTU	CENTER NG/J	LOWER BOUNDARY LB/10**6 BTU	LOWER BOUNDARY NG/J	UPPER BOUNDARY LB/10**6 BTU	UPPER BOUNDARY NG/J
1	.194	83.	.165	71.	.223	96.
2	.252	108.	.223	96.	.281	121.
3	.310	133.	.281	121.	.339	146.
4	.368	158.	.339	146.	.397	171.
5	.426	183.	.397	171.	.455	195.
6	.484	208.	.455	195.	.513	220.
7	.542	233.	.513	220.	.571	245.
8	.600	258.	.571	245.	.629	270.
9	.658	283.	.629	270.	.687	295.
10	.716	308.	.687	295.	.745	320.

NOx PROBABILITY RESULTS

CELL NUMBER	NUMBER OF ENTRIES	CUM. PROB. PERCENT LESS THAN
1	41	2.22
2	268	16.75
3	342	35.28
4	360	54.80
5	356	74.09
6	232	86.67
7	114	92.85
8	86	97.51
9	37	99.51
10	8	99.95

(continued)

TABLE 8-2. (CONTINUED)

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                       **NOX COMPLIANCE WITH RESPECT TO 1971 NSPS**
            FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
              FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)
      FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)
            FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)
                       THIS BOILER WAS OPERATED WITH SUBBITUMINOUS COAL
          THE NOX MEASURED DURING THE PERFORMANCE TEST WAS   .490  LB/10**6 BTU (210. NG/J)
AN ANALYSIS OF 3-HOUR NO. ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
            INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     2  OCCASIONS
AN ANALYSIS OF 3-HOUR NO. BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)
            INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     2  OCCASIONS
```

(continued)

TABLE 8-2. (CONTINUED)

NOX COMPLIANCE WITH RESPECT TO 1978 NSPS

1978 NSPS NOX EMISSION LIMITATIONS
SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)

ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED 0 EXCEEDANCES

30-DAY ROLLING AVERAGES
EMISSION LIMITATION .50 LB/10**6 BTU 215. NG/J

SEQUENTIAL AVERAGE	30-DAY AVERAGE NO LB/10**6 BTU	NG/J
1	.368	158.
2	.373	160.
3	.376	162.
4	.377	162.
5	.379	163.
6	.381	164.
7	.381	164.
8	.383	165.
9	.386	166.
10	.389	167.
11	.391	168.
12	.392	168.
13	.388	167.
14	.387	166.
15	.387	166.
16	.388	167.
17	.389	167.
18	.392	168.
19	.391	168.
20	.390	168.
21	.391	168.
22	.391	168.
23	.388	167.
24	.385	165.
25	.383	164.
26	.380	163.
27	.378	162.
28	.374	161.
29	.370	159.
30	.366	157.
31	.367	158.
32	.366	157.
33	.365	157.
34	.366	157.
35	.365	157.
36	.368	158.
37	.372	160.
38	.377	162.
39	.384	165.
40	.392	169.
41	.398	171.
42	.403	173.
43	.413	177.
44	.422	181.
45	.423	182.
46	.425	183.
47	.425	183.
48	.428	184.
49	.435	187.

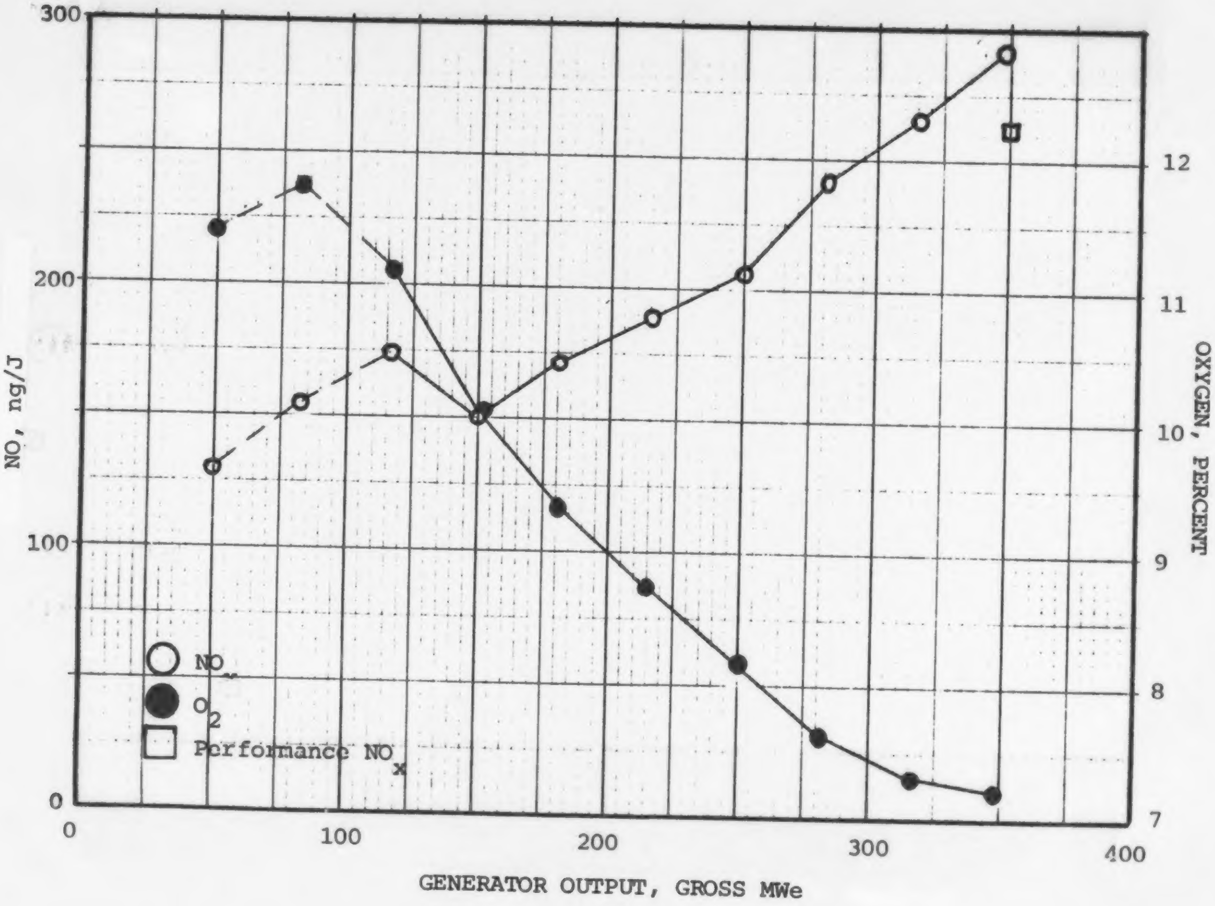

Figure 8-1. Unit A - Boiler Characteristics

8-3

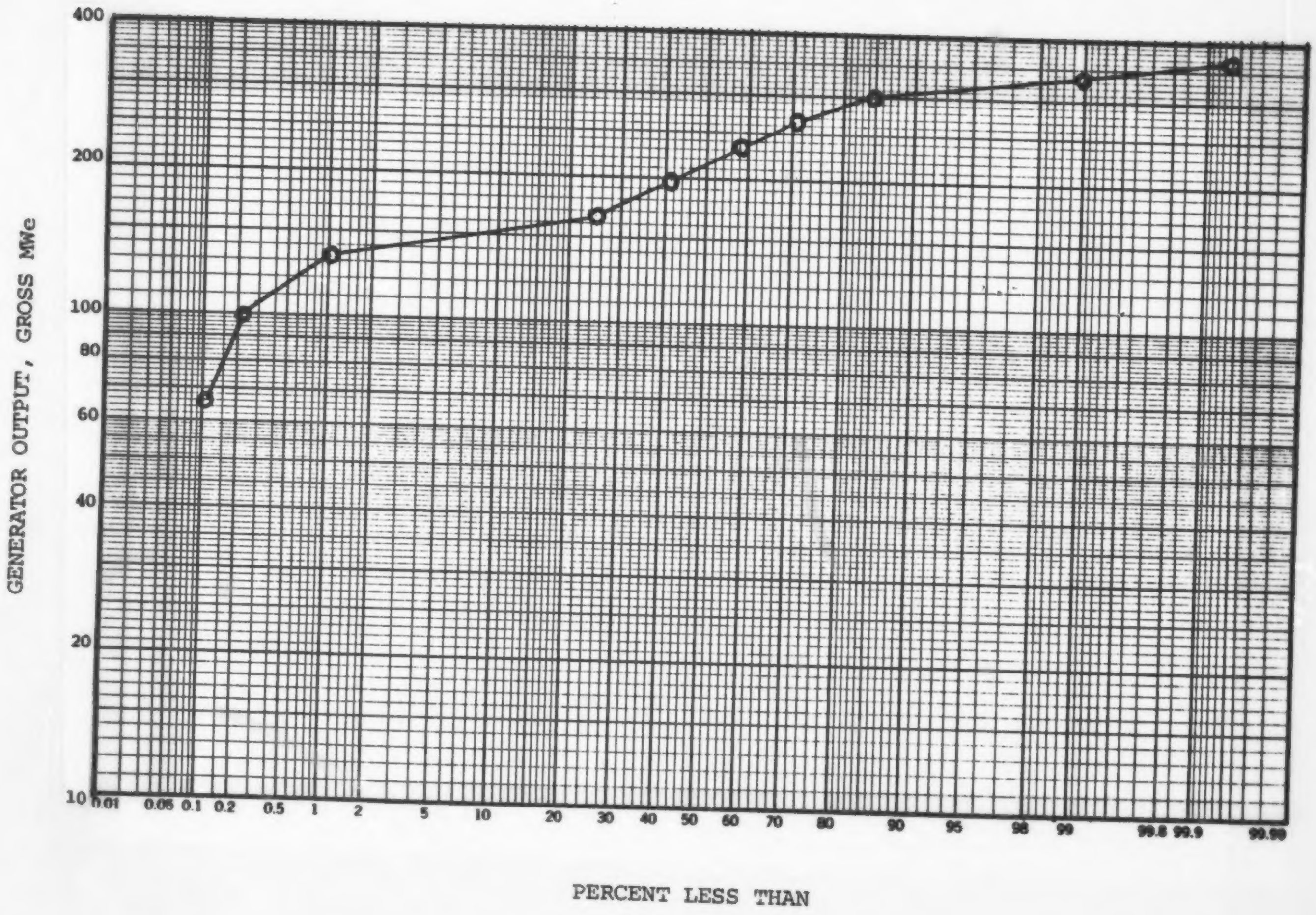

Figure 8-2. Unit A - Load Probability

8-4

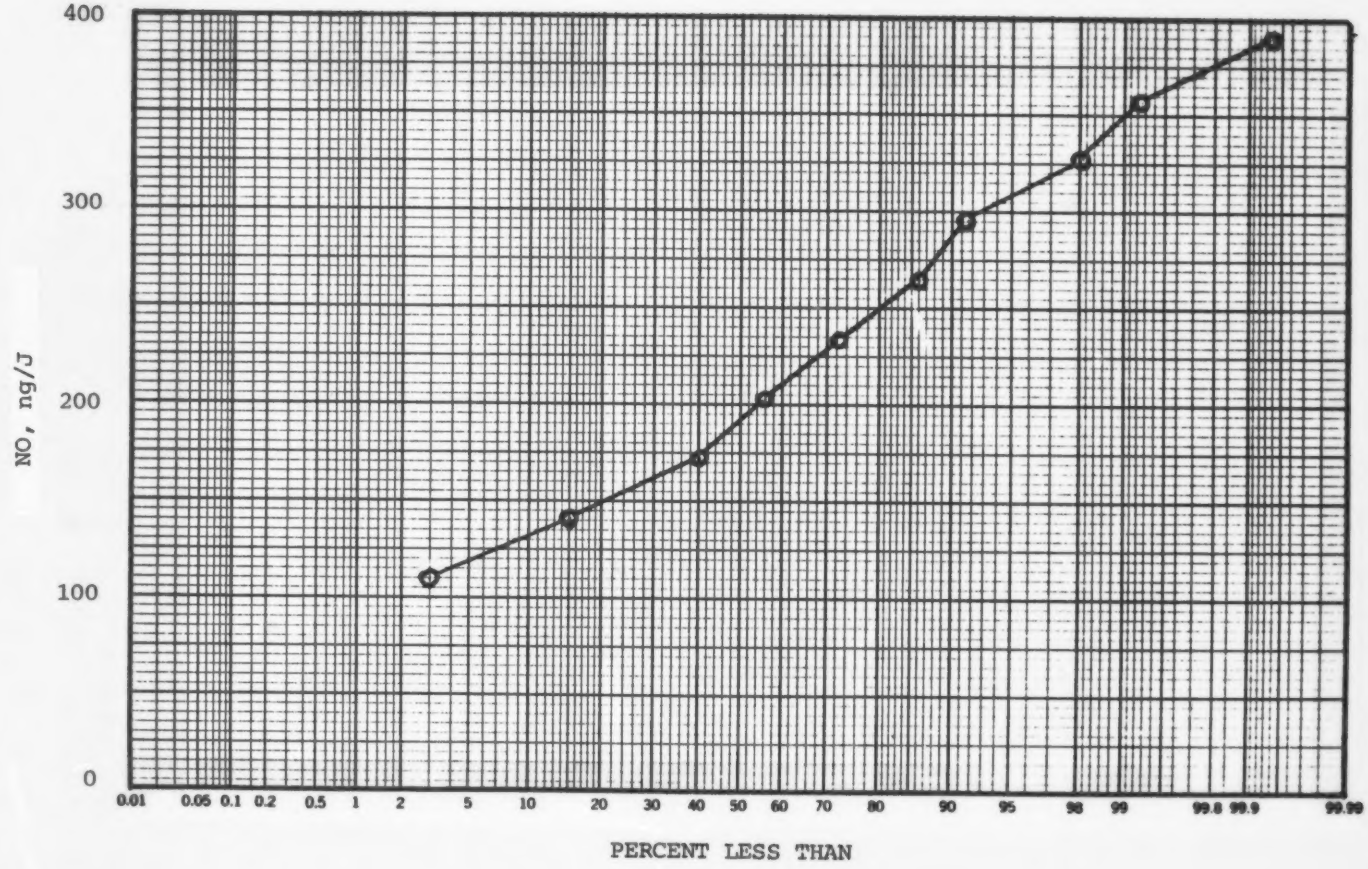

Figure 8-3. Unit A - NO Probability

8-3

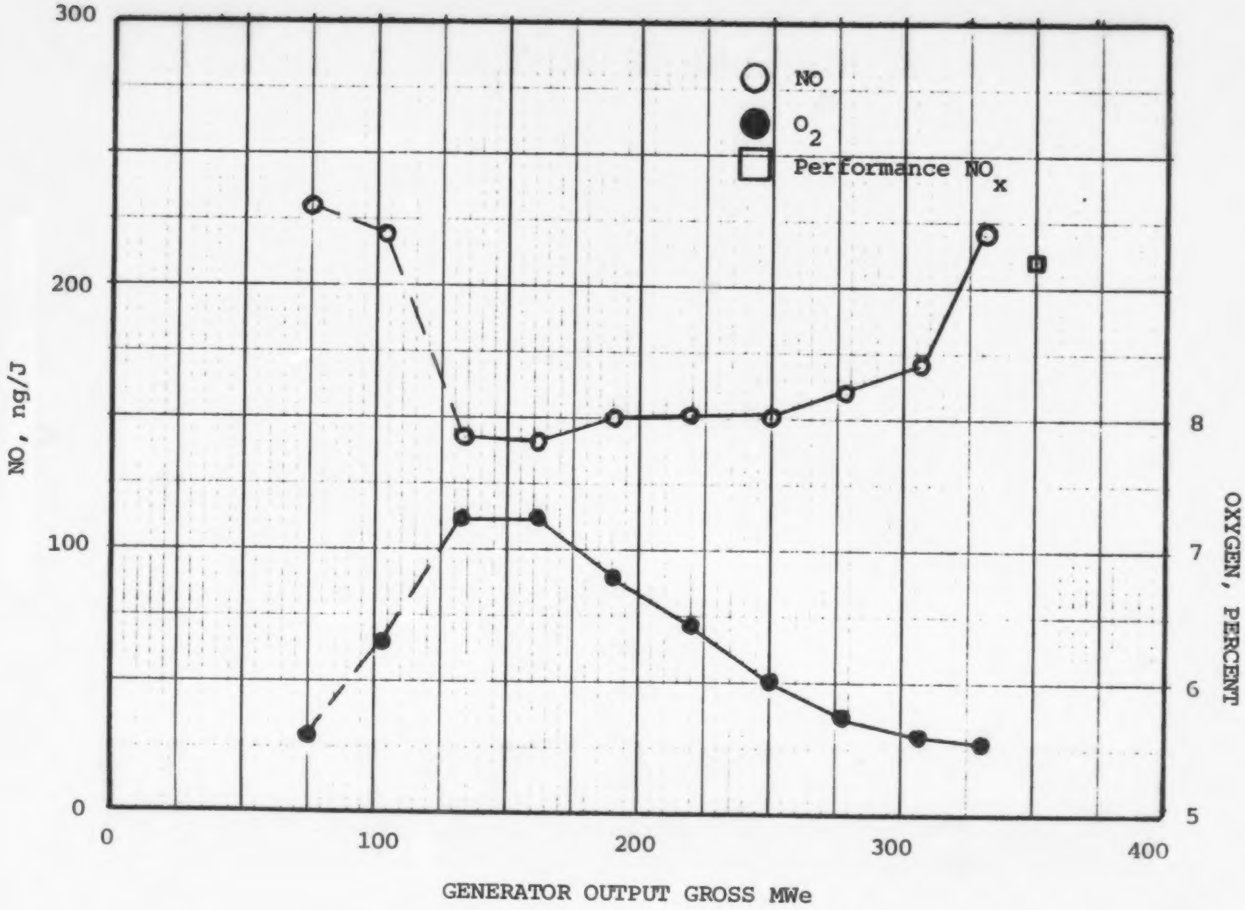

Figure 8-4. Unit B - Boiler Characteristics

8-6

exceed the value measured during the performance test. The load probability (Figure 8-5) is representable only by its median value --- 265 gross MWe (75.7 percent of rating). A comparison of the median loads indicates that Unit B is more heavily loaded than Unit A. The NO probability (Figure 8-6) is nearly log-normal distributed, however, it is best characterized in terms of the median --- 163 ng/J. Even though Unit B is operated at a higher load, its median NO is lower than Unit A's.

With respect to the 1971 NSPS, Unit B's analysis indicates two periods of excess NO emissions on both 3-hour rolling and 3-hour block averaged bases. Unit B would have complied with the 1978 NSPS performance test for subbituminous coal and would not have had any periods of excess emissions on a 30-day rolling average basis even if the monitor measurement was increased by 3 percent to account for NO_2. The maximum 30-day rolling average was 87 percent of the standard.

Figure 8-7 compares the NO boiler characteristics for Units A and B. As noted, these characteristics begin to diverge above a load of 150 gross MWe and differ by approximately 63 ng/J (28.6 percent) at high load. The O_2 comparison for Units A and B is shown in Figure 8-8, and are not directly comparable since the measurement for Unit A is made downstream of a wet scrubber.

The utility supplied a total of 61 proximate analyses of moisture, ash, sulfur and heating value for the January-March 1981 time period. The analyses were for coal samples from each train arriving at the station and it was not possible to relate these samples to the time when the coal was burned in the boilers. Table 8-3 summarizes these coal analyses, with the dry, ash-free heating value calculated by KVB.

The utility also supplied five ultimate analyses of coal taken from the bunkers and Table 8-4 presents the results. Of note are the fairly low values of fuel nitrogen content. Based on the proximate and ultimate analyses it is assessed that the coal properties were constant during the monitoring period.

(text continued on page 8-25)

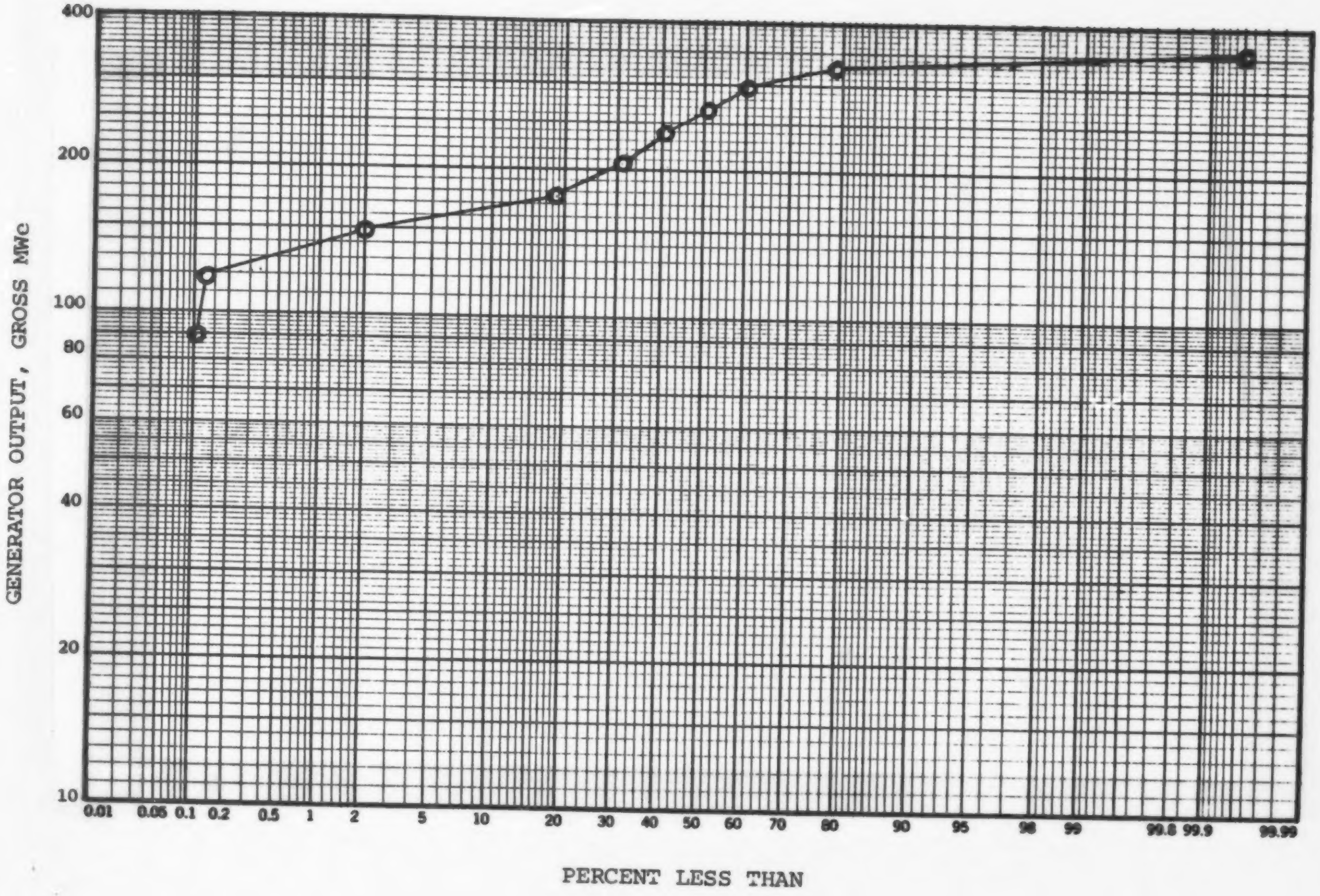

Figure 8-5. Unit B - Load Probability

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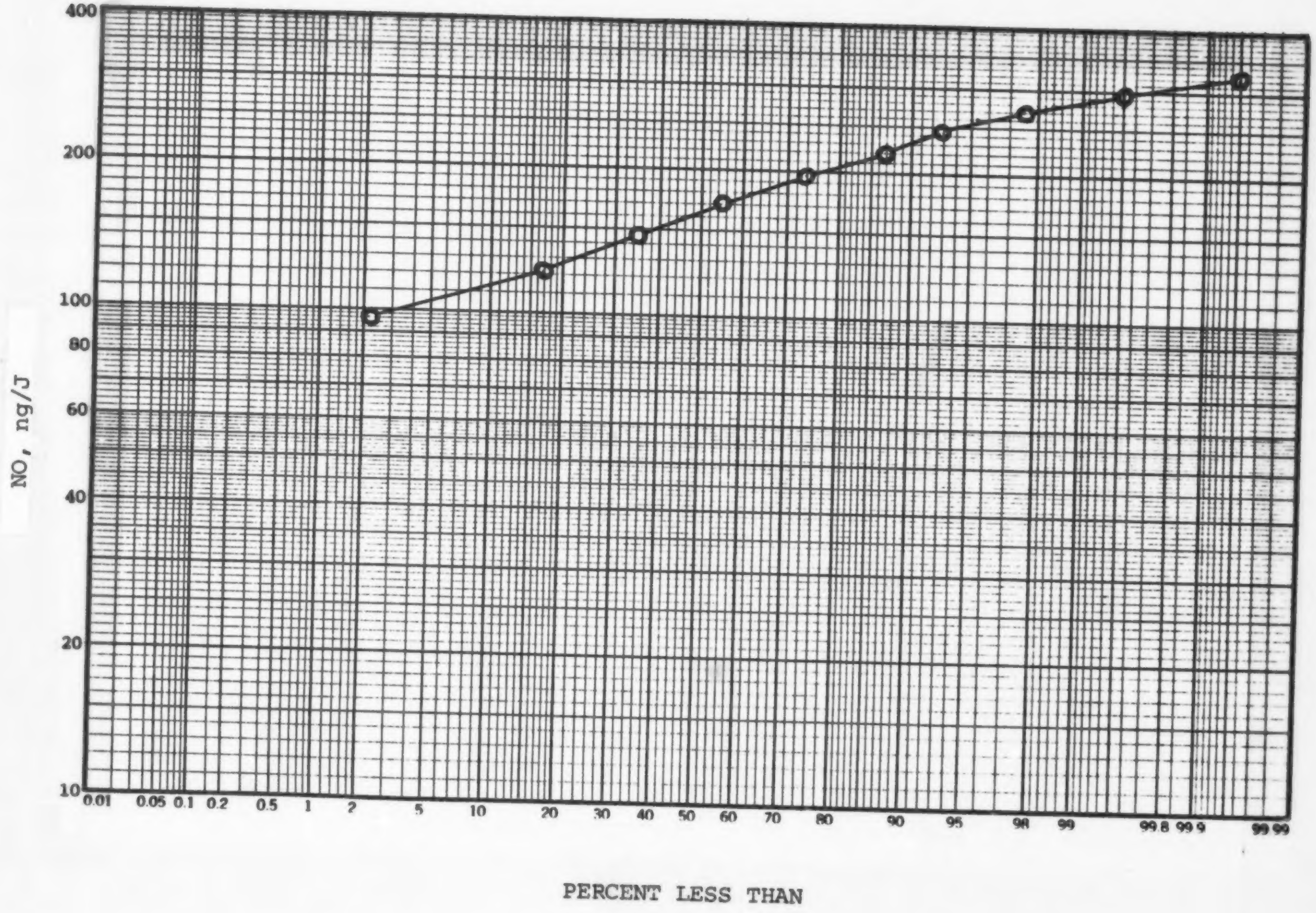

Figure 8-6. Unit B - NO Probability

8-8

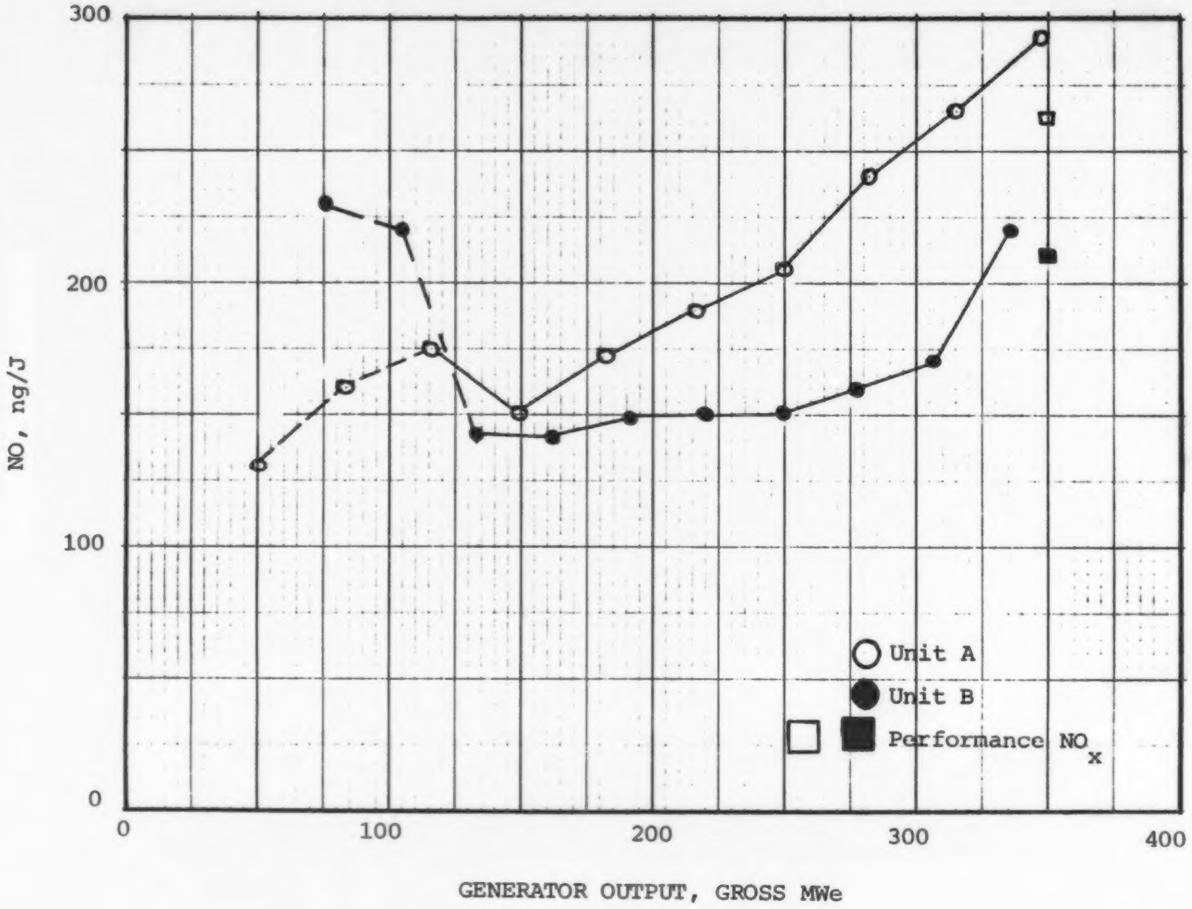

Figure 8-7. Units A and B - NO Comparison

8-7

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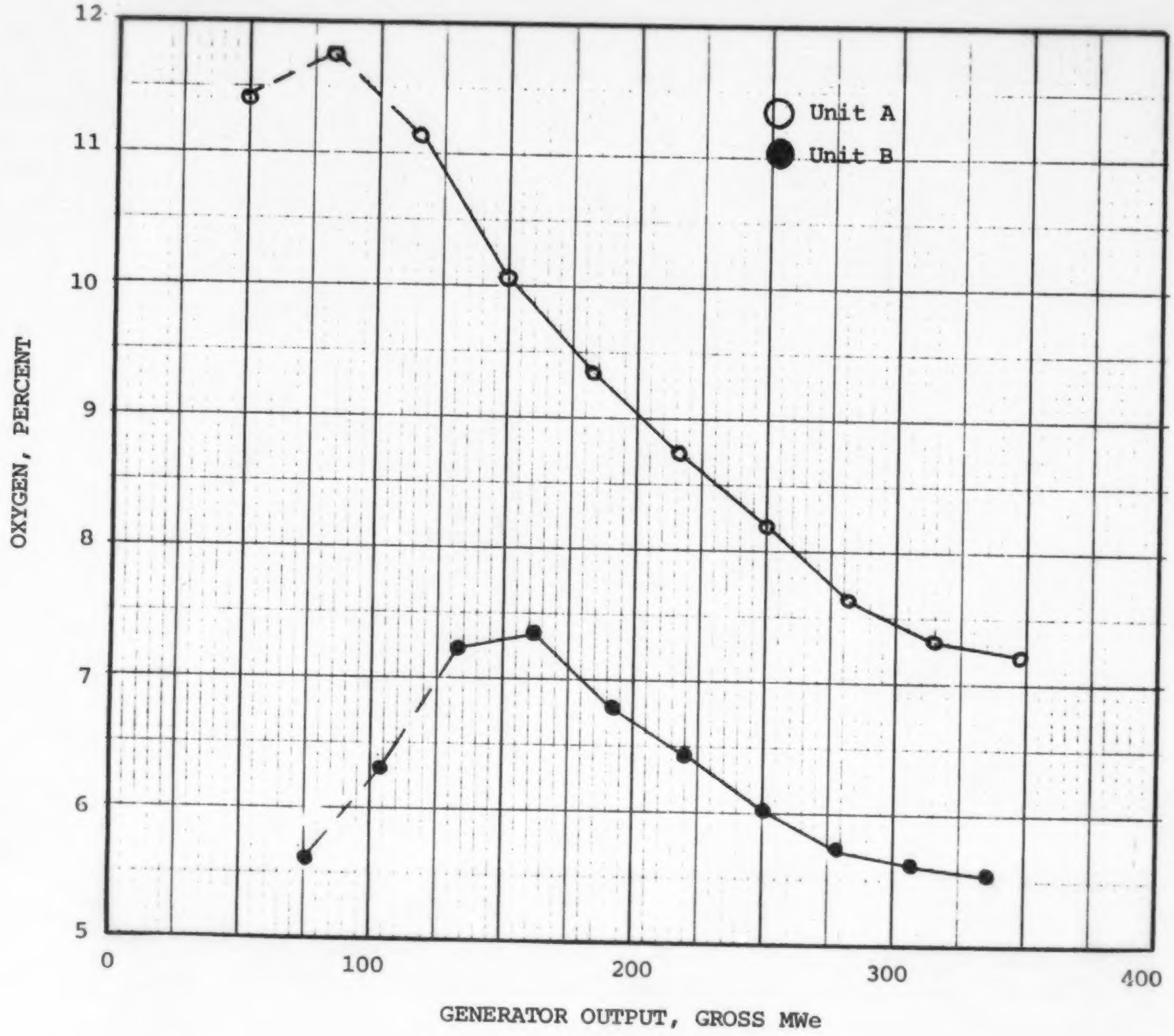

Figure 8-8. Units A and B - Oxygen Comparison

8-10

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TABLE 8-3. COAL PROXIMATE ANALYSES - UNITS A AND B

(1981)

	Jan.	Feb.	March	Jan. - March
Number of Samples	18	20	23	61
Moisture, %	27.78	28.07	28.24	28.05
Stand. Dev., %	0.23	0.43	0.72	0.55
Ash, %	4.59	4.60	4.54	4.57
Stand. Dev., %	0.14	0.22	0.45	0.31
Sulfur, %	0.41	0.42	0.39	0.41
Stand. Dev., %	0.03	0.03	0.04	0.04
Btu/lb (kJ/kg)	8821 (20,518)	8793(20,453)	8767 (20,392)	8791 (20,448)
Stand. Dev., Btu/lb (kJ/kg)	30 (70)	63 (147)	91(212)	37 (86)
Dry, Ash-Free Btu/lb (kJ/kg)	13,043 (30,338)	13,059 (30,375)	13,036 (30,322)	13,048 (30,350)

TABLE 8-4. COAL ULTIMATE ANALYSES - UNITS A AND B
(AS RECEIVED)

	SAMPLE 1	2	3	4	5
Moisture	25.69	28.16	28.49	25.92	26.06
Carbon	49.55	50.76	50.77	51.98	51.83
Hydrogen	3.47	3.60	3.49	3.68	3.81
Nitrogen	0.70	0.88	0.84	0.73	0.88
Chlorine	-	-	0.04	0.00	0.04
Sulfur	0.39	0.35	0.36	0.41	0.39
Ash	5.01	4.36	4.39	5.05	4.99
Oxygen (by diff.)	15.19	11.89	11.62	12.12	12.00
Btu/lb	8861	8777	8733	8958	8899
kJ/kg	20,611	20,415	20,313	20,836	20,699
Dry Ash-Fee					
Btu/lb	12,786	13,007	13,011	12,977	12,906
kJ/kg	29,741	30,254	30,264	30,184	30,020

Appendices K and L is the hourly-average input for the data reduction computer program.

8.2 SITE VISIT

On August 18, 1981, a meeting was held with station personnel responsible for operation of the units and continuous emission monitoring (CEM) systems. The following information was obtained.

8.2.1 Boiler Design

a. Boiler Description

- Boiler manufacturer is Combustion Engineering (CE).
- Burner design is tilting tangential with overfire air (OFA) above top row of burners.
- Five levels of coal burners with the OFA nozzles above the fifth coal burner and a refuse injection nozzle and corresponding air nozzles above the OFA.
- Coal fired is Wyoming subbituminous.
- Furnace heat release is 14,771 Btu/ft^3.
- Generator rated at 343 MWe gross, but typically operates at 360 MWe gross.

b. OFA tilts with the burners and the angle between the OFA and burners is 0 deg. The OFA dampers are manually operated to control NO_x emissions.

8.2.2 Operational Items

- O_2 operation: Both units operate with O_2 curves designed into the combustion control system and operate with ~10 percent O_2 at 30 percent load down to 4.0 percent O_2 at 100 percent load.
- Heat Rate: Unit A averages ~10,300 Btu/kWh net (9556 gross, with auxiliary usage of 26 MWe). Unit B averages ~9975 Btu/kWh net (9421 gross, with auxiliary usage of 20 MWe.)
- Steam Temperatures: Both units are able to maintain design temperatures of 1000/1000°F SH/RH without any problem.
- OFA Operation: Both units' OFA operation are manually controlled. The operation is left to the discretion of the operator and is variable from one operator to the next. Unit A operates

with the NO_x damper somewhat more open than Unit B. No records exist to quantify this difference. Also, the damper opening may vary from one day to another depending on operator and existing conditions, e.g., coal variations, etc. Unit B operates with tilts higher than those on Unit A. Unit A operates with lower tilts to avoid excessive steam temperature.

- Slagging/Fouling Characteristics: Both units have experienced slagging problems and are typically limited to ~five days at full load operation before having to de-slag. Typical operation is as follows: The units operate near full load for 2-3 days then drop load rapidly to shed slag (drop load at a rate of 10 MWe/min for 50 MWe; let boiler stabilize, then drop load again; this is continued until 150 MWe is reached.) The units then operate at 150 MWe for at least 4-6 hours in order to de-slag. Water lances have been installed in the furnace burner zone to control slagging on Unit B. The water lances are usually operated at least once per shift. Both units have experienced fouling problems. Unit B has plugged up in the arch area, reheat and economizer sections. Unit A has plugged up in the economizer and air heaters. The only means of controlling these deposits is by soot-blowing. The soot blowing cycle is computerized and cleans selected zones as necessary. The soot-blowing system utilizes 300 psig air. The utility plans to install additional soot-blowers in the superheat and economizer sections to improve control of deposits in these areas.
- Unit Availability: The only availability problem has been related to fan limitations on Unit B due to excessive pressure drops experienced in the baghouse.
- Ash Carbon Characteristics: No data available.
- Tube Wastage: None identified.
- NO Emissions Excursions: Unit A occasionally experiences NO excursions at full load.

8.2.3 Continuous Emissions Monitoring System

- Make and Model: The CEMS for both units are Lear Siegler SM 800's. The utility has made substantial modifications to the SM 800's to improve their reliability and performance. The primary problem with the SM 800's was related to the temperature compensation card. Both monitors measure NO only and not NO_x.
- Monitor Certification Dates:

Unit A: December 1976
Unit B: October 1978

- CEM Location: The Unit A CEM location is in the transition duct between the scrubber outlet and the stack. The Unit B CEM is located at 220 ft level of the 300 ft stack.

- Oxygen Analyzers; CEM/Boiler: Boiler oxygen levels are measured in the ducts before the air heaters and both boiler's oxygen operation is very similar. Oxygen levels are also measured after the air heaters at the CEM locations given above. The Unit A CEM oxygen level is typically higher than Unit B due primarily to leakage in Unit A's ESP and wet scrubber system.

- CEM Data Reduction: The CEMs are certified to strip charts and computer. The utility calculates their own "F" factor based on coal analyses. The data reduction procedures for Units A and B are shown in Figures 8-9 and 8-10, respectively. Note that the Unit A data is moisture compensated.

- Monitor Certification:

  (1) The original certification data for Units A and B showed that the NO_x relative accuracy was 32 percent and 6.5 percent respectively. The certification test summaries for both are shown in Tables 8-5 and 8-6. Unit A NO analyzer was subsequently retested and achieved a relative accuracy of 8.0 percent.

  (2) Neither unit's CEM has undergone re-certification. The utility has conducted their own EPA Method 7 testing occasionally and reports that these test results agree, within EPA's specifications of 20 percent, with the corresponding CEM NO measurements.

  (3) Relative accuracy tests are not regularly scheduled.

- Calibration Procedure:

  (1) Description - The CEMs use a glass cell, filled with the appropriate calibration reference gases, inserted into the light path.

  (2) Operation - The CEMs go through an automatic calibration check every 24 hours. Re-calibration adjustments are performed manually as required.

- Quality Assurance Procedures: The computer lists all failures and alarms and a person is assigned to checking the list each morning and following up on the necessary problems. There are no written quality assurance procedures.

- CEM Operation and Availability History: No significant operational or availability problems have been encountered since the utility completed their own series of modifications to the original SM 800's.

(text continued on page 8-32)

The magnitude of excess emissions computed in accordance with 40CRFR60.13(h) is obtained by converting the continuous monitoring system's data using the following conversions:

1. The average concentrations in ppm ($\bar{C}$) of SO_2 and NO_x are converted from a wet basis to a dry basis by:

$$\bar{C}_{dry} = \bar{C}_{ws} \frac{100\%}{(100\% - H_2O\%)}$$

2. The percentages for O_2 are converted from a wet basis to a dry basis by:

$$\%O_{2\ dry} = \%O_{2\ ws} \frac{100\%}{(100\% - \%H_2O)}$$

3. The dry basis SO_2 and NO_x average concentrations ($\bar{C}_{dry}$) are reduced from ppm pollutant and percent O_2 to lb/million Btu by the following expression:

$$E = \bar{C}_{dry}(2.59 \times 10^{-9} \text{ lb/dscf per ppm})\ (M)\ (\bar{F}) \frac{20.9}{20.9 - \%O_{2\ dry}}$$

where:

M = 64.07 for SO_2 and 46.01 for NO_x

$\bar{F}$ = the previous 1-hour average of F, prorated according to the factors and the percent of total heat inputs derived from subbituminous coal and gaseous fossil fuels.

Figure 8-9. Excess Emissions Conversion Factors
Unit A

The magnitude of excess emissions is computed in accordance with 40 CFR60.13(h).

The average concentrations ($\bar{C}_{ws}$) in ppm of SO_2 and NO_x and the percent O_2 ($\%O_{2\ ws}$) are measured on a wet basis at stack conditions. They are reduced to pollutant emissions (E) in lb/million Btu using the alternative data reduction procedures* as follows:

$$E = \bar{C}_{ws}\ (2.59 \times 10^{-9}\ \text{lb/wscf per ppm})\ (M)\ (\bar{F}_w)\ \frac{20.9}{20.9\ (1 - B_{wa}) - \%O_{2\ ws}}$$

where:

M = 64.07 for SO_2 and 46.01 for NO_x

$\bar{F}_w$ = the previous 1-hour average of F_w, prorated according to the F_w factors and the percent of total heat inputs derived from subbituminous coal and gaseous fossil fuels.

B_{wa} = proportion by volume of water vapor in the ambient air.

*Emission Monitoring Requirements
Federal Register, Vol. 41, No. 198
Tuesday, October 12, 1976, pp 44838 and 44839

Figure 8-10. Excess Emissions Conversion Factors
Unit B

TABLE 8-5. ORIGINAL NO CERTIFICATION RESULTS - UNIT A

Parameter	Test Results	EPA Specifications
1. Accuracy*		
a. computer	32.27%†	$\leq$ 20%
b. recorder	33.51%	$\leq$ 20%
2. Calibration error*		
a. high range	1.1%	$\leq$ 5%
b. mid range	2.0%	$\leq$ 5%
3. Zero drift* (2h)		
a. computer	0.172%	$\leq$ 2% of span
b. recorder	0.056%	$\leq$ 2% of span
4. Zero drift* (24h)		
a. computer	0.28%	$\leq$ 2% of span
b. recorder	0.15%	$\leq$ 2% of span
5. Calibration drift* (2h)		
a. computer	0.836%	$\leq$ 2% of span
b. recorder	1.901%	$\leq$ 2% of span
6. Calibration drift* (24h)		
a. computer	2.20%	$\leq$ 2.5% of span
b. recorder	2.04%	$\leq$ 2.5% of span
7. Response time	1.9 minutes	15 minutes
8. Operational period	168 hours	168 hours

*Expressed as sum of absolute mean value plus 95% confidence interval

†Subsequently certified at 8.0%

TABLE 8-6. NO CERTIFICATION RESULTS - UNIT B

Parameter	Test Results	EPA Specifications
1. Accuracy*		
a. computer	6.5%	≤ 20%
b. recorder	6.0%	≤ 20%
2. Calibration error* (supplied by Lear Siegler)		
a. high range	0.5%	≤ 5%
b. mid range	1.0%	≤ 5%
3. Zero drift* (2h)		
a. computer	0.2%	2% of span
b. recorder	0.3%	2% of span
4. Zero drift* (24h)		
a. computer	0.2%	2% of span
b. recorder	0.3%	2% of span
5. Calibration drift* (2h)		
a. computer	0.7%	2% of span
b. recorder	0.5%	2% of span
6. Calibration drift* (24h)		
a. computer	0.5%	2.5% of span
b. recorder	0.7%	2.5% of span
7. Response time (supplied by Lear Siegler)	1.0 minutes	15 minutes
8. Operational period	168 hours	168 hours

*Expressed as sum of absolute mean value plus 95% confidence interval of a series of tests.

8.2.4 Evaluation of NO Deviation Between Units A and B

The plausible explanation of why Unit A NO emissions are higher than Unit B is related to the burner tilt operation. Unit A is a "hotter" boiler than Unit B, i.e., at the same firing rate more heat is transferred in the convective pass on Unit A than on Unit B. To control excesssive steam temperatures on Unit A then, it is necessary to operate with the tilts downward. Operating with the tilts downward results in increased NO production.

8.2.5 Coal

The coal supply is from one mine: the Black Thunder (ARCO) mine in Gillete, Wyoming.

SECTION 9.0

PUBLIC SERVICE COMPANY OF NEW MEXICO - SAN JUAN STATION UNIT 1

9.1 EMISSIONS ANALYSIS

Data supplied for this unit covered the 89-day period of January 1 to March 30, 1981. A total of 1,266 hours of monitor data was used in the analysis with the difference (870 hours) due mainly to the boiler being off-line or no data being supplied by the utility. When these two factors are excluded, the monitor reliability, defined as the ratio of monitor to boiler operating hours, is 90.6 percent.

The computer analysis of the monitor data (Table 9-1) indicates that this unit is a fairly low NO emission source. This unit is subject to the more stringent state of New Mexico NO_x limitation (0.45 $lb/10^6$ Btu - 194 ng/J) and its operation is governed by achieving this limitation. The original EPA NSPS performance test resulted in an emisison factor of 0.627 $lb/10^6$ Btu (270 ng/J). However, in a test conducted for the state on March 5, 1980, the emission factor was measured as 0.35 $lb/10^6$ Btu (151 ng/J). Much of this difference is attributed to a burner development program sponsored by Foster-Wheeler. Reference 4 describes this program.

Daily boiler operation, as discussed in Section 9.2, is primarily to comply with the state limitation. To this end the operating station is equipped with a CO monitor strip-chart (part of the original design) and displays of NO and O_2. Unit operation is at the lowest practical O_2 consistent with a low CO concentration (<200 ppm).

The "spiky" nature of the boiler O_2 characteristic (Figure 9-1) is probably due to the use of heated ambient air which is mixed with the flue gas exiting the four-module wet SO_2 scrubber. This indirect reheat system is designed to maintain the flue gas above 175°F (353 K) and avoid acid condensation in the stack.

(text continued on page 9-9)

TABLE 9-1. COMPUTER ANALYSIS SUMMARY - SAN JUAN UNIT 1

```
                    **PULVERIZED COAL-FIRED UTILITY BOILER NO  EMISSION MONITORING**
PUB. SERV. NEW MEXICO SAN JUAN PLANT UNIT 1
FOSTER WHEELER BOILER =OVERFIRE AIR AND DUAL REG. BRNS  360 MWE GROSS
PERFORM. NOX=0.627 LB/10**6BTU (270 NG/J). REDUCED TO 0.35 LB/10**6BTU
(151 NG/J) FOR STATE COMPLIANCE.  SUBBITUMINOUS COAL
NO  MONITOR RELATIVE ACCURACY = 10.5 PC
DAY 1 = 1 JANUARY 1981
```

(continued)

TABLE 9-1. (CONTINUED)

DAILY MEANS AND STANDARD DEVIATIONS

DAY	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD MEAN MW	LOAD STD DEV MW
1	.357	150.	.0607	26.1	8.5	1.48	278.	41.9
2	.404	174.	.0211	9.1	9.4	1.42	289.	63.7
3	.413	177.	.0198	8.5	9.2	.65	361.	1.3
5	.423	182.	.0227	9.7	9.0	.61	361.	3.8
6	.475	204.	.0236	10.2	9.3	.14	361.	3.1
7	.433	186.	.0438	18.8	9.1	.58	345.	21.9
8	.435	187.	.0150	6.5	8.0	.97	359.	5.0
9	.457	196.	.0161	6.9	8.5	.79	357.	9.4
10	.526	226.	.0986	42.4	10.6	1.04	242.	111.7
11	.384	165.	.0427	18.4	9.7	.81	249.	52.4
12	.386	166.	.0324	13.9	9.5	1.33	297.	55.4
13	.392	168.	.0261	11.2	9.6	.93	320.	10.7
14	.407	175.	.0170	7.3	10.4	.35	307.	22.7
15	.419	180.	.0250	10.8	10.8	.41	294.	63.3
16	.411	177.	.0210	9.0	10.6	1.02	292.	38.8
17	.399	171.	.0198	8.5	10.3	.30	311.	55.0
18	.415	178.	.0150	6.5	10.5	.16	321.	2.1
19	.397	171.	.0143	6.1	10.3	.24	322.	1.9
20	.382	164.	.0211	9.1	10.4	.29	328.	6.3
21	.407	175.	.0178	7.6	10.8	.12	328.	3.4
22	.404	174.	.0147	6.3	10.9	.13	319.	57.5
23	.376	161.	.0206	8.9	8.9	1.28	329.	9.4
24	.386	166.	.0138	5.9	9.8	.74	334.	6.1
25	.382	164.	.0110	4.7	10.5	.27	300.	38.4
26	.387	166.	.0311	13.4	10.5	.50	324.	17.4
27	.374	161.	.0490	21.1	10.5	1.25	320.	13.5
28	.391	168.	.0106	4.6	10.5	.37	306.	61.1
29	.386	166.	.0143	6.2	9.6	.53	327.	22.4
30	.381	164.	.0183	7.8	10.2	.34	336.	3.2
31	.384	165.	.0280	12.0	10.5	.39	319.	22.5
33	.400	172.	.0163	7.0	10.5	.73	330.	9.3
34	.405	174.	.0270	11.6	10.7	.16	329.	.9
35	.407	175.	.0146	6.3	10.8	.55	329.	1.4
36	.392	168.	.0131	5.6	10.2	.21	328.	5.1
38	.390	168.	.0795	34.1	14.9	1.82	142.	52.5
42	.439	188.	.0296	12.7	9.3	.30	278.	52.0
43	.415	178.	.0226	9.7	9.2	.29	287.	6.7
44	.330	142.	.0245	10.5	8.2	.34	299.	58.4
45	.361	155.	.0472	20.3	10.7	1.30	237.	83.0
46	.309	133.	.0731	31.4	9.1	1.42	287.	72.9
47	.366	157.	.0742	31.9	7.6	1.01	299.	10.8
48	.389	167.	.0462	19.9	10.2	1.14	238.	36.3
49	.485	208.	.0817	35.1	11.3	.59	256.	20.5
51	.458	197.	.0821	35.3	11.3	2.11	190.	47.6
52	.430	185.	.0426	18.3	7.7	1.68	267.	18.3
53	.409	176.	.0543	23.3	7.4	1.12	288.	35.1
58	.426	183.	.0118	5.1	7.2	.14	361.	1.3
59	.391	168.	.0273	11.7	7.1	.13	345.	66.5
60	.358	154.	.0394	16.9	7.2	.38	340.	26.7
61	.419	180.	.0350	15.0	7.3	.52	347.	34.3
62	.440	189.	.0451	19.4	7.6	1.61	333.	38.6
63	.404	174.	.0289	12.4	7.5	.63	301.	70.8
64	.384	165.	.0428	18.4	9.1	1.48	317.	46.2
85	.415	178.	.1335	57.4	9.2	3.15	270.	90.6
86	.408	175.	.0073	3.1	7.8	.26	336.	10.9
87	.412	177.	.0159	6.8	8.1	.09	322.	3.6
89	.412	177.	.0186	8.0	8.9	1.10	319.	4.0

(continued)

TABLE 9-1. (CONTINUED)

NO AND O2 SORTED BY LOAD CELL, AND LOAD PROBABILITY

LOAD CELL DIMENSIONS

CELL NUMBER	CENTER(MW)	LOWER BOUNDARY(MW)	UPPER BOUNDARY(MW)
1	29.	11.	47.
2	65.	47.	82.
3	100.	82.	118.
4	136.	118.	154.
5	172.	154.	189.
6	207.	189.	225.
7	243.	225.	261.
8	279.	261.	297.
9	314.	297.	332.
10	350.	332.	368.

RESULTS OF LOAD SORTING

CELL NUMBER	NO. OF ENTRIES	NO MEAN LB/10**6 BTU	NO MEAN NG/J	NO STD DEV LB/10**6 BTU	NO STD DEV NG/J	O2 MEAN PERCENT	O2 STD DEV PERCENT	LOAD PROB. PERCENT
1	9	.332	143.	.2119	91.0	13.26	5.12	.71
2	9	.387	166.	.0406	17.5	9.98	2.54	1.42
3	15	.403	173.	.0726	31.2	15.33	1.02	2.60
4	2	.465	200.	.0212	9.1	13.75	.07	2.76
5	6	.322	138.	.1151	49.5	11.27	1.73	3.24
6	88	.416	179.	.0955	41.0	10.91	1.23	10.18
7	57	.435	187.	.0791	34.0	9.20	1.95	14.68
8	159	.408	175.	.0475	20.4	9.13	1.39	27.23
9	526	.391	168.	.0359	15.4	9.73	1.27	68.75
10	395	.417	179.	.0363	15.6	8.77	1.36	99.92

(continued)

TABLE 9-1. (CONTINUED)

NO PROBABILITY

NO CELL DIMENSIONS

CELL NUMBER	CENTER LB/10**6 BTU	NG/J	LOWER BOUNDARY LB/10**6 BTU	NG/J	UPPER BOUNDARY LB/10**6 BTU	NG/J
1	.079	34.	.045	19.	.113	49.
2	.147	63.	.113	49.	.181	78.
3	.215	92.	.181	78.	.249	107.
4	.283	122.	.249	107.	.317	136.
5	.351	151.	.317	136.	.385	165.
6	.419	180.	.385	165.	.453	195.
7	.487	209.	.453	195.	.521	224.
8	.555	238.	.521	224.	.589	253.
9	.623	268.	.589	253.	.657	282.
10	.691	297.	.657	282.	.725	311.

NO PROBABILITY RESULTS

CELL NUMBER	NUMBER OF ENTRIES	CUM. PROB. PERCENT LESS THAN
1	3	.24
2	0	.24
3	6	.71
4	39	3.79
5	330	29.83
6	763	90.06
7	98	97.79
8	18	99.21
9	6	99.68
10	3	99.92

(continued)

TABLE 9-1. (CONTINUED)

```
                    **NOX COMPLIANCE WITH RESPECT TO 1971 NSPS**

       FOR SUBBITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)

        FOR BITUMINOUS COAL THE EMISSION LIMITATION IS 0.70 LB/10**6 BTU (300 NG/J)

FOR LIGNITE MINED IN THE DAKOTAS OR MONTANA THE EMISSION LIMITATION IS 0.80 LB/10**6 BTU (340 NG/J)

       FOR OTHER LIGNITE COALS THE EMISSION LIMITATION IS 0.60 LB/10**6 BTU (260 NG/J)

                   THIS BOILER WAS OPERATED WITH SUBBITUMINOUS COAL

      THE NOX MEASURED DURING THE PERFORMANCE TEST WAS   .350  LB/10**6 BTU (150. NG/J)

AN ANALYSIS OF 3-HOUR NO  ROLLING AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)

         INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     0  OCCASIONS

AN ANALYSIS OF 3-HOUR NO  BLOCK AVERAGES (EXCLUDING PERIODS WHEN THE BOILER WAS OFF-LINE OR MONITOR INOPERATIVE)

         INDICATED THAT THE NOX EMISSION LIMITATION WAS EXCEEDED ON     0  OCCASIONS
```

(continued)

TABLE 9-1. (CONTINUED)

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          **NOX COMPLIANCE WITH RESPECT TO 1978 NSPS**

               1978 NSPS NOX EMISSION LIMITATIONS
          SUBBITUMINOUS COAL = 0.50 LB/10**6 BTU (210 NG/J)
            BITUMINOUS COAL = 0.60 LB/10**6 BTU (260 NG/J)
LIGNITE MINED IN DAKOTAS OR MONTANA = 0.80 LB/10**6 BTU (340 NG/J)
            OTHER LIGNITES = 0.60 LB/10**6 BTU (260 NG/J)


 ANALYSIS OF 30-DAY ROLLING AVERAGES INDICATED     0  EXCEEDANCES

                    30-DAY ROLLING AVERAGES
       EMISSION LIMITATION  .50 LB/10**6 BTU  215. NG/J

            SEQUENTIAL          30-DAY AVERAGE NO.
             AVERAGE           LB/10**6 BTU  NG/J
            ----------         ------------  ----
                    1              .406      175.
                    2              .408      175.
                    3              .408      175.
                    4              .408      175.
                    5              .407      175.
                    6              .404      174.
                    7              .403      173.
                    8              .403      173.
                    9              .399      171.
                   10              .393      169.
                   11              .391      168.
                   12              .390      167.
                   13              .390      167.
                   14              .392      169.
                   15              .394      169.
                   16              .395      170.
                   17              .395      170.
                   18              .395      170.
                   19              .395      170.
                   20              .394      169.
                   21              .395      170.
                   22              .396      170.
                   23              .397      171.
                   24              .397      171.
                   25              .398      171.
                   26              .399      171.
                   27              .400      172.
                   28              .401      172.
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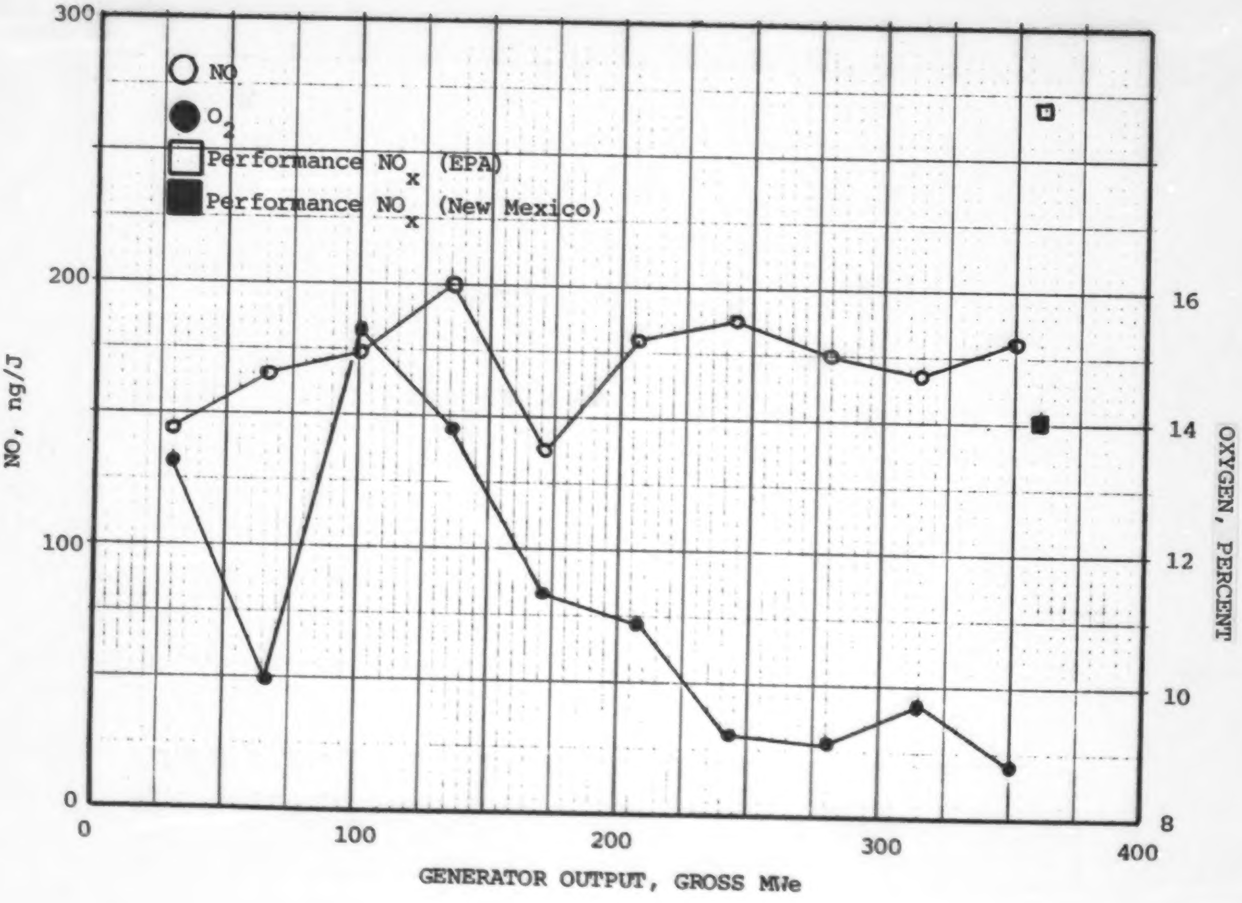

Figure 9-1. San Juan Unit 1 - Boiler Characteristics

9-2

9-9

The load distribution (Figure 9-2) is not represented in either normal or log-normal coordinates. The median load, however, is 317 gross MWe (88.1 percent of rating). The median NO (Figure 9-3) is 173 ng/J.

F2
3

As noted, this unit would have complied with the 1978 NSPS performance test and would not have resulted in any periods of excess emissions on a 30-day rolling average basis. The maximum 30-day rolling average is 81.6 percent of the NO_x standard.

The coal is supplied by a co-located dedicated mine. The utility furnished the daily proximate analyses of heating value and sulfur content for the January - March 1981 time period. These analyses are summarized in Table 9-2. The maximum difference in the monthly-averaged heating value is 1.7 percent, and 4.6 percent for the mean sulfur content. The utility also supplied ultimate analyses obtained over a five-year period with the results presented in Table 9-3.

T2
3

A definitive assessment of coal property constancy requires that the moisture and ash content be also determined (Reference 3). This is illustrated by the heating value results shown in Table 9-3 where on an as-received basis the maximum difference is 18.9 percent. However, on a dry, ash-free basis the maximum difference in heating value is only 1.2 percent. The coal proximate analyses supplied to KVB were on an as-received basis without specification of either moisture or ash content, therefore, it is not possible to make a definitive assessment of coal property constancy.

The extractive continuous emission monitor (CEM) draws a flue gas sample from the stack 320 ft. (98 m) elevation. The sample is pumped to the analyzers (ground mounted) through a heated line. Calibration gases, in accordance with EPA requirements, are introduced at the sample probe and also flow through the heated sample line. The analyzer is measuring NO only and not total NO_x and no correction is made to account for NO_2. The NO and O_2 analyzer certification test results are presented in Tables 9-4 and 9-5. These tests were performed from July 30 to August 3, 1979. The 24-hour drift tests were repeated during October 11-19, 1980 for the purpose of certification through the computer.

T4
5

The computer program input data is contained in Appendix M.

(text continued on page 9-16)

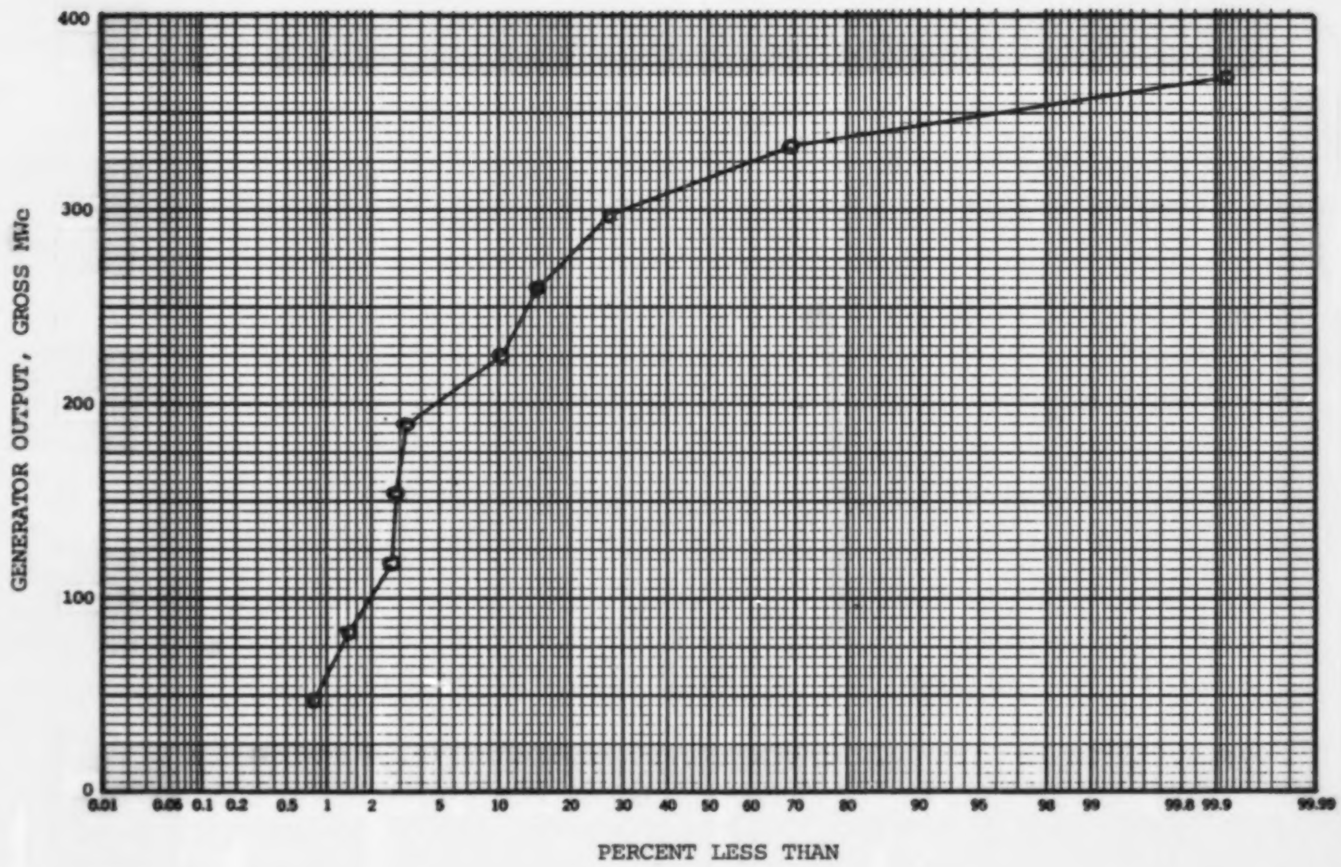

Figure 9-2. San Juan Unit 1 - Load Probability

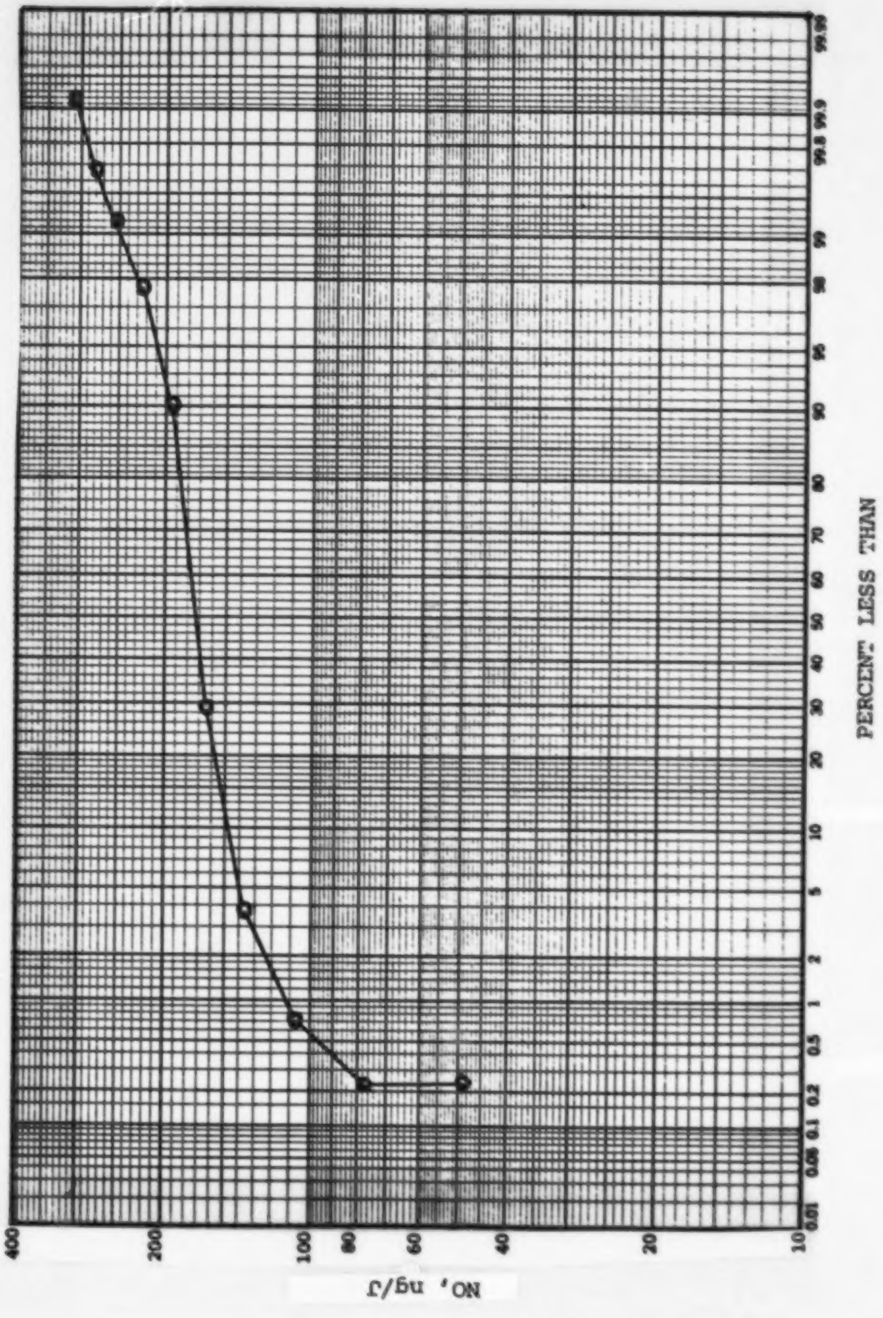

Figure 9-3. San Juan Unit 1 - NO Probability

9-4

9-12✓

TABLE 9-2. COAL PROXIMATE ANALYSES - SAN JUAN UNIT 1

Parameter	Jan. 1981	Feb. 1981	March 1981	Jan.-March 1981
Number of Samples	29	28	25	82
Mean Heating Value Btu/lb (kJ/kg)	10,130 (23,560)	10,090 (23,470)	10,260 (23,860)	10,150 (23,610)
Heating Value Stand. Dev. Btu/lb (kJ/Kg)	280 (650)	260 (600)	200 (470)	250 (580)
Mean Sulfur Content, %	0.90	0.88	0.92	0.90
Sulfur Content Stand. Dev.,%	0.073	0.055	0.069	0.067

TABLE 9-3. COAL ULTIMATE ANALYSES - SAN JUAN UNIT 1

Parameter	March 4, 1975	August 31, 1978	March 6, 1980
Moisture	6.28	9.11	0.61
Carbon	56.99	51.88	61.45
Hydrogen	4.40	4.04	4.78
Nitrogen	1.30	0.98	1.43
Chlorine	0.01	0.01	0.09
Sulfur	0.79	0.89	0.81
Ash	20.27	23.58	20.27
Oxygen (diff.)	9.96	9.51	10.56
Btu/lb	10,131	9,191	10,929
kJ/kg	23,565	21,378	25,421
Dry, Ash-Free			
Btu/lb	13,793	13,655	13,813
kJ/kg	32,083	31,762	32,129

TABLE 9-4. NO ANALYZER CERTFICATION TEST RESULTS - SAN JUAN UNIT 1

Parameter	EPA Specification	Test Result
Relative Accuracy	≤ 20%	10.5%
Zero Drift (2-hr)	≤ 2% of span	0.44%
Zero Drift (24-hr)*	≤ 2% of span	0.26%
Calibration Drift (2-hr)	≤ 2% of span	1.77%
Calibration Drift (24-hr)*	≤ 2.5% of span	1.38%
Calibration	≤ 5% of span (mid-range)	1.78%
	≤ 5% of span (high-range)	1.70%
Response Time	15 min. maximum	1.56 min.
Operation Period	168 hr. minimum	168 hr.

*Waiver obtained to perform these tests on an 8-hour period.

TABLE 9-5. O_2 ANALYZER CERTIFICATION TEST RESULTS - SAN JUAN UNIT 1

Parameter	EPA Specification	Test Result
Zero Drift (2-hr)	$\leq$ 0.4% O_2	0.40% O_2
Zero Drift (24-hr)*	$\leq$ 0.5% O_2	0.05% O_2
Calibration Drift (2-hr)	$\leq$ 0.4% O_2	0.40% O_2
Calibration Drift (24-hr)*	$\leq$ 0.5% O_2	0.17% O_2
Response Time	10 min. maximum	Not Obtained
Operational Period	168 hr. minimum	168 hr.

*Waiver obtained to perform these tests on an 8-hour period.

9.2 SITE VISIT

On September 10, 1981, a meeting was held with Mr. Hank Taylor, Environmental Coordinator, and Mr. Joseph Gonzales, Operations Supervisor. This unit is subject to the more stringent NO_x regulations imposed by the State of New Mexico (0.45 lb/10^6 Btu - 194 ng/J) and unit operation is dictated by these regulations.

9.2.1 Boiler Design

- Boiler manufacturer is Foster Wheeler.
- Burner design is dual register with overfire air ports above top burner row.
- Front-face faced with 16 burners in 4 x 4 pattern.
- Furnace heat release rate is 11,640 Btu/hr-ft^3 at 95 percent of maximum continuous rating.
- New Mexico subbituminous coal.
- Generator rated at 360 MWe gross.

9.2.2 Operation Items

- O_2 Operation: The furnace O_2 is maintained as low as practical to limit NO emissions. The control room is equipped with a strip-chart output of CO and a cathode ray tube presentation of O_2 and NO. If the NO approaches the alarm level then the operator will reduce O_2 consistent with maintaining the CO at an appropriate level. The CO measurement is a composite based on multi-point sampling in the economizer section.
- Heat Rate: The operating heat rate is approximately 10,000 Btu/kWh.
- Steam Temperature: The unit is able to maintain design temperatures of 1005/1005°F (SH/RH) without any problem.
- OFA Operation: The overfire air ports, located above the top burner row, are closed and not used.
- Burner Operation: The burner register settings are not adjusted with unit load. The settings were previously determined during a test program.

- Slagging/Fouling: Occasionally a clinker forms in the convective section, however, the unit has never been shut-down for clinker bridging in the nose region.

- Unit Availability: The only availability problem has been due to mill operation.

- Ash Carbon Characteristics: Flyash samples analyzed during 1976 and 1979 showed carbon contents of 1.51, 1.22, 1.09, and 0.37 percent.

- Tube Erosion: High gas velocity, due to clinker formation in the convective section, has caused a minor amount of tube wastage.

- NO Emissions Excursions: Only occur during upset conditions, e.g., unit breakdown or mill startup.

9.2.3 Continuous Emissions Monitoring System

- Make and Model: The extractive CEM was assembled by KVB and includes a Thermo Electron Corp. Model 10AR NO_x analyzer and a Teledyne Model 326A Oxygen analyzer. The system is measuring NO only and not NO_x.

- Monitor Certification Dates:

  July 30 - August 5, 1979
  October 11 - 19, 1980

  The latter date was a retest of the 24-hour drift tests for O_2 and NO for the purpose of certification through the computer.

- CEM Location: The sample location is at the 320 ft. level on the 400 ft. stack. The CEM is ground mounted. The sample location follows a hot-side ESP and wet SO_2 scrubber.

- Oxygen Analyzers; CEM/Boiler: The wet scrubber outlet includes a steam coil reheat system to heat ambient air to a level such that when mixed with flue gas the stack exit temperature is at or above 175°F (353K). This reheat system, in combination with air heater leakage, causes the stack excess oxygen reading to be 3-4 percentage points higher than measured in the economizer. At the time of the visit to the control room the stack O_2 was 9.96 percent (without reheat) while the economizer O_2 was 6.34 percent. However, the corresponding unit load was not recorded.

- CEM Data Reduction: The CEM is certified through the computer since there are no strip-charts. The measured NO and O_2 are on a dry basis with the NO corrected to a standard 3 percent O_2 dilution. An "F" factor of 0.001366 is used to convert the dry, corrected NO from ppm to lb NO (as NO_2)/10^6 Btu.

- Monitor Certification:

  -- The certification test data showed that the NO relative accuracy was 10.5 percent.

  -- The CEM has not been recertified and relative accuracy tests are not planned.

- Calibration Procedure: The CEM is auto-calibrated every 8-hours using certified gases introduced at the sampling location. In this manner the calibration gas encounters the same environment as does the flue gas. The computer compares the monitor readings with the known calibration gas composition and develops factors which correct the monitor for both span and zero drift.

- Quality Assurance Procedure: A written check-sheet is filled out on a daily basis. This sheet is reviewed to identify potential monitor problems, i.e., sample line, probe, probe filter. In addition, the entire system is leak checked once-a-week.

- CEM Operation and Reliability History: No significant operational problems have been experienced. Monitor reliability, defined as the ratio of CEM operating hours to boiler operating hours, was 97.5 percent for the 4th quarter of 1980, 81.4 percent for the 2nd quarter of 1981, 94.0 percent for the third quarter of 1981, and 96.6 percent for the fourth quarter. Mr. Taylor indicated that monitor reliability is a direct function of monitor maintenance.

9.2.4 Coal

The subbituminous coal is supplied from an adjacent mine.

9.2.5 Flue Gas Desulfurization and Particulate Control

FGD is accomplished by a four-cell wet SO_2 scrubber. Reheat of the flue gas is by indirect means--ambient air is heated by steam coils and is then mixed with the flue gas. An electrostatic precipitator is located upstream of the primary air heaters.

SECTION 10.0

CONCLUSIONS AND RECOMMENDATIONS

This study reached two major conclusions:

1. Low NO emissions are achievable when unit air flow is carefully controlled.

2. Seven of the nine boilers analyzed would have produced no periods of excess NO emissions on a 30-day rolling average basis. The same seven boilers would have complied with the 1978 NSPS performance test requirement.

The two conclusions are based on the information presented in Table 10-1 which summarizes the analyses of the nine boilers. For example, this summary indicates that for the initial analysis for Muskogee Unit 4:

1. 94-days of valid data were used in the analysis.

2. With respect to the 1971 NSPS, this unit was found to exceed the 3-hour emission limitation on -

   17 occasions for rolling average basis
   6 occasions for block average basis

3. With respect to the 1978 NSPS, this unit would have complied with the performance test and would have had no periods of excess emissions ("Actual"). (The column headed "Maximum" is the number of 30-day rolling averages each of which is a potential period of excess emissions.)

The 30-day rolling averages were analyzed to determine the number of periods of excess emission at 90 percent of the applicable 1978 NSPS standard. This analysis would identify those units which would have had some margin with respect to the standard. The result of this analysis is shown in Table 10-2. A comparison between Tables 10-1 and 10-2 indicates that only Muskogee 4 and Unit A would have had a significant increase in periods of excess emissions at 90 percent of the 1978 NSPS standard.

TABLE 10-1. ANALYSIS SUMMARY

Boiler	Coal Type(1)	1978 NSPS Performance ng/J	Number of Valid Days	1971 NSPS NO_x Exceedances Rolling	1971 NSPS NO_x Exceedances Block	1978 NSPS NO_x Exceedances Actual	1978 NSPS NO_x Exceedances Maximum
Muskogee 4	Sub.	208	94	17	6	0	65
Revised(4)		207	78	17	6	0	49
Muskogee 5	Sub.	179	82	16	6	0	53
Revised(4)		(3)	21(3)	5	2	--	--
Nebraska City 1	Sub.	228(2)	31	30	12	2	2
Council Bluffs 3	Sub.	141	96	0	0	0	67
Revised(4)		138	63	0	0	0	34
Homer City 3	Bit.	274(2)	61	161	60	32	32
Mill Creek 3	Bit.	210	54	0	0	0	25
Unit A	Sub.	189	75	75	31	0	46
Unit B	Sub.	158	78	2	2	0	49
San Juan 1	Sub.	175	57	0	0	0	28

(1) Sub. = Subbituminous

Bit. = Bituminous

(2) Would not have complied with 1978 NSPS performance test.

(3) Insufficient data to calculate 30-day rolling average.

(4) Revised analysis performed after deleting data of questionable validity.

TABLE 10-2. PERIODS OF EXCESS EMISSIONS AT 90 PERCENT OF 1978 NSPS.

Boiler	Actual	Maximum
Muskogee 4	65	65
Revised	49	49
Muskogee 5	3	53
Revised	*	*
Nebraska City 1	2	2
Council Bluffs 3	0	67
Revised	0	34
Homer City 3	32	32
Mill Creek 3	0	25
Unit A	35	46
Unit B	0	49
San Juan 1	0	28

*Insufficient data to calculate 30-day rolling averages.

Table 10-3 presents the monitor reliabilities (monitor/boiler operating hours) determined from the hourly-averaged data. Excluding Nebraska City 1 the average monitor reliability for the initial analyses was 91.7 percent with a standard deviation of 5.6 percent. The revised analyses, which were conducted after the site visits, show lower reliabilities because of deleting monitor data which were found to be of questionable validity. The primary reason for the deletion was that the NO analyzer periodic calibration had exceeded certain preset limits.

Of particular interest are the results for Council Bluffs Unit 3 and San Juan Unit 1. Each of these units are operated at closely controlled low excess air with the assistance of a permanently installed CO monitor. The reasons for this operating mode differs for the two units:

Council Bluffs - induced draft fan limitation and
fuel efficiency

San Juan 1 - more stringent state NO_x limitation

However, the overall result obtained for each unit is similar, namely, low NO emissions with respect to both the 1971 and 1978 NSPS requirements.

It is recommended that operation of these two units be examined in more detail in order to assess to what extent this mode of operation could be adopted by other pulverized coal-fired utility boilers. This assessment will include coordination with the major boiler manufacturers.

The difference in emission characteristics between Muskogee 4 and 5 is presently unexplained. Attempts to reconcile this difference in terms of constructional and operational details was unsuccessful. This unexplained difference may be attributable to monitor calibration procedures.

It is recommended that the monitor strip-chart records for Muskogee 5 be reviewed to establish the amount by which the monitor exceeded the daily calibration range. This difference will then be used to correct the hourly-averaged monitor measurements to determine if the daily calibration procedure is responsible for the apparent difference in emission characteristics.

Recently, the in situ monitor on Homer City 3 has been calibrated with certified gases instead of with a reference cell. The comparison has shown

TABLE 10-3. MONITOR RELIABILITY

Boiler	Reliability, %(1)
Muskogee 4	99.7
Revised	79.2
Muskogee 5	99.1
Revised	23.2
Nebraska City 1	(2)
Council Bluffs 3	95.1
Revised	62.1
Homer City 3	85.6
Mill Creek 3	86.5
Unit A	89.6
Unit B	87.3
San Juan 1	90.6

(1) (Monitor/boiler operating hours) • 100.

(2) Fifteen calendar months required to accumulate 31 days of data.

that calibration with the reference cell results in measured NO levels approximately 20 percent higher than calibration with the certified gases. This difference might be due to an incorrectly filled reference cell or a basic characteristic of some types of monitors. It is recommended that this matter be pursued further by contacting the monitor manufacturer to verify the reference cell composition and operation of the temperature compensating circuits during the calibration mode. This activity should be coordinated with the EPA contractors who are performing NO_x monitor audits.

The 1971 and 1978 NSPS NO_x requirements differ in two major aspects:

1. Performance standard.
2. Averaging period.

Table 10-1 indicates that seven of the nine boilers analyzed would have complied with the more stringent 1978 performance standard. Except for Nebraska City 1 and Homer City 3 there would have been no periods of excess emissions on a 30-day rolling average basis. This result should be compared to the more frequent exceedances on the 3-hour rolling or block averaging basis. Thus, although the 1978 NSPS performance standard is more stringent the use of a longer averaging time results in fewer periods of excess emissions.

The operation of base-loaded units, as illustrated by Homer City 3, would make compliance with the 1978 NSPS performance test more difficult to achieve. For these units it is not possible to "average in" periods of potentially lower NO emissions at lower loads, i.e., the NO emission at rated load would have to be at or below the applicable standard.

On the other hand, for units which operate with normal load cycles it is possible to take advantage of lower emissions at lower loads. This is illustrated by Unit A which shows (Figure 8-3) that 38 percent of the hourly-averaged data points were above the 1978 NSPS standard for subbituminous coal ($0.5\ lb/10^6 Btu$ - 215 ng/J). Despite this, Unit A would have complied with the 1978 NSPS performance test and would have had no periods of excess NO emissions.

Based on these observations, it is noted that base-loaded units behave differently with respect to 30-day NO rolling averages since they do not have the operational flexibility to "average in" periods of potentially lower NO emissions at the lower loads.

SECTION 11.0

REFERENCES

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3. Private communication with Mr. Sidney Kaplan (Commercial Testing and Engineering Co.), September, 16, 1981.

4. Vatsky J., "Development and Field Operation of the Controlled Flow/Split - Flame Burner," Proceedings: Joint Symposium on Stationary Combustion NO_x Control, October 6-9, 1980, Denver, Colorado, IERL-RTP-1083, October 1980.